24th Annual National Conference on Managing Environmental Quality Systems

8:30 – 12:00 TUESDAY, APRIL 12TH - A.M. Stockholder Meetings

12:00 – 4:30 TUESDAY, APRIL 12TH
Opening Plenary (Salons A-H)

- Opening Address
  - Reggie Cheatham, Director, OEI Quality Staff, EPA
  - Linda Travers, Principal Deputy Assistant Administrator, OEI, EPA
- Invited Speakers
  - Tom Huetteman, Deputy Assistant Regional Administrator, EPA Region 9
  - John Robertus, Executive Officer of San Diego Regional Water Quality Control Board, Region 9
- Keynote Address
  - Thomas Redman, President, Navesink Consulting Group
- Panel Sessions
- **Value of the Data Quality Act—Perspectives from OMB, Industry, and EPA (VDQA)**
  - Nancy Beck, OMB
  - Jamie Conrad, American Chemistry Council
  - Reggie Cheatham, Director, OEI Quality Staff, EPA
- **Wadeable Streams: Assessing the Quality of the Nation's Streams (WS)**
  - Margo Hunt, Panel Moderator
  - Mike Shapiro, Deputy Assistant Administrator, Office of Water
  - Steve Paulsen, Research Biologist, ORD

8:30 – 10:00 WEDNESDAY, APRIL 13TH
Environmental Measures (EM) (Salons A-C) *Chair: L. Bradley, EPA*

- Data Error Reduction by Automation throughout the Data Workflow Process (A. Gray, EarthSoft, Inc.)
- Analytical Approaches to Meeting New Notification Levels for Organic Contaminants in Calif. (D.Wijekoon, Calif. DHS)
- Streamlining Data Management and Communications for the Former Walker AFB Project (R. Amano, Lab Data Consultants, Inc.)

Quality System Implementation in the Great Lakes Program (QSI-GLP) (Salon D) *Chair: M. Cusanelli, EPA*

- GLNPO's Quality System Implementation for the New "Great Lakes Legacy Act for Sediment Remediation"(L. Blume, EPA)
- Black Lagoon Quality Plan Approval by GLNPO, MDEQ, ERRS, and USACE (J. Doan, Environmental Quality Management, Inc.)
- Remediation of the Black Lagoon Trenton Channel . . . Postdredging Sampling & Residuals Analysis (J. Schofield, CSC)

Quality Systems Models (QSM) (Salons F-H) *Chair: G. Johnson, EPA*

- Improving E4 Quality System Effectiveness by Using ISO 9001: 2000 Process Controls (C. Hedin, Shaw Environmental)

Applications of Novel Techniques to Environmental Problems (ANTEP) (Salon E) *Chair: B. Nussbaum, EPA*

- On Some Applications of Ranked Set Sampling (B. Sinha, University of Maryland)
- Combining Data from Many Sources to Establish Chromium Emission Standards (N. Neerchal, University of Maryland)
- Estimating Error Rates in EPA Databases for Auditing Purposes (H. Lacayo, Jr., EPA)
- Spatial Population Partitioning Using Voronoi Diagrams For Environmental Data Analysis (A. Singh, UNLV)

Ambient Air Session I (Sierra 5&6) *Chair: M.Papp, EPA*

- Changes and Improvements in the Ambient Air Quality Monitoring Program Quality System (M. Papp, EPA)
- Guidance for a New Era of Ambient Air Monitoring (A. Kelley, Hamilton County DES)
- Environmental Monitoring QA in Indian Country (M. Ronca-Battista, Northern Arizona University)
- Scalable QAPP IT Solution for Air Monitoring Programs (C. Drouin, Lake Environmental Software)

10:30 – 12:00 WEDNESDAY, APRIL 13TH

Environmental Laboratory Quality Systems (ELQS) (Salons A-C) *Chair: L. Bradley, EPA*

- A Harmonized National Accreditation Standard: The Next Step for INELA Field Activities (D. Thomas, Professional Service Industries, Inc.)
- Development of a Comprehensive Quality Standard for Environmental Laboratory Accreditation (J. Parr, INELA)
- Advanced Tracking of Laboratory PT Performance and Certification Status with Integrated Electronic NELAC-Style Auditing Software (T. Fitzpatrick, Lab Data Consultants, Inc.)

Performance Metrics (PM) (Salon D) *Chair: L. Doucet, EPA*

- Formulating Quality Management Metrics for a State Program in an Environmental Performance Partnership Agreement (P. Mundy, EPA)
- How Good Is "How Good Is?" (Measuring QA) (M. Kantz, EPA)
- Performance-Based Management (J. Santillan, US Air Force)

Quality Assurance Plan Guidance Initiatives (QAPGI) (Salons F-H) *Chair: A. Batterman, EPA*

- A CD-ROM Based QAPP Preparation Tool for Tribes (D. Taylor, EPA)
- Military Munitions Response Program Quality Plans (J. Sikes, U.S. Army)

Ask a Statistician: Panel Discussion (Salon E) *Moderator: B. Nussbaum, EPA* Panelists:

- Mike Flynn, Director, Office of Information Analysis and Access, OEI, EPA
- Reggie Cheatham, Director, Quality Staff, OEI, EPA
- Tom Curran, Chief Information Officer, OAQPS, EPA
- Diane Harris, Quality Office, Region 7, EPA
- Bill Hunt, Visiting Senior Scientist, North Carolina State University (NCSU)
- Rick Linthurst, OIG, EPA

Ambient Air Session II (Sierra 5&6) *Chair: M. Papp, EPA*

- National Air Toxics QA System and Results of the QA Assessment (D. Mikel, EPA)
- Technical System Audits (TSAs) and Instrument Performance Audits (IPAs) of the National Air Toxics Trends Stations (NATTS) and Supporting Laboratories (S. Stetzer Biddle, Battelle)
- Interlaboratory Comparison of Ambient Air Samples (C. Pearson, CARB)
- Developing Criteria for Equivalency Status for Continuous PM2.5 Samplers (B. Coutant, Battelle)

1:00 – 2:30 WEDNESDAY, APRIL 13TH

Environmental Laboratory Quality (ELQ) (Salons A-C) *Chair: L. Doucet, EPA*

- Environmental Laboratory Quality Systems: Data Integrity Model and Systematic Procedures (R. DiRienzo, DataChem Laboratories, Inc.)
- The Interrelationship of Proficiency Testing, Interlaboratory Statistics and Lab QA Programs (T. Coyner, Analytical Products Group, Inc.)
- EPA FIFRA Laboratory Challenges and Solutions to Building a Quality System in Compliance with International Laboratory Quality Standard ISO 17025 (A. Ferdig, Mich. Dept. of Agriculture)

Performance—Quality Systems Implementation (P-QSI) (Salon D) *Chair: A. Belle, EPA*

- Implementing and Assessing Quality Systems for State, Tribal, and Local Agencies (K. Bolger, D. Johnson, L. Blume, EPA)

1:00 – 2:30 WEDNESDAY, APRIL 13TH (continued)

Quality Initiatives in the EPA Office of Environmental Information (QI-OEI) (Salons F-H) *Chair: J. Worthington, EPA*

- Next Generation Data Quality Automation in EPA Data Marts (P. Magrogan, Lockheed)
- The Design and Implementation of a Quality System for IT Products and Services (J. Scalera, EPA)
- Data Quality is in the Eyes of the Users: EPA's Locational Data Improvement Efforts (P. Garvey, EPA)

A Win-Win-Win Partnership for Solving Environmental Problems (W3PSEP) (Salon E) *Co-Chairs: W. Hunt, Jr. and K. Weems, NCSU*

- Overview of Environmental Statistics Courses at NCSU (B. Hunt, NCSU Statistics Dept.)
- Overview of the Environmental Statistics Program at Spelman College (N. Shah, Spelman)
- Student presentations: H. Ferguson and C. Smith of Spelman College; C. Pitts, B. Stines and J. White of NCSU

Ambient Air Session III (Sierra 5&6) *Chair: M. Papp, EPA*

- Trace Gas Monitoring for Support of the National Air Monitoring Strategy (D. Mikel, EPA)
- Comparison of the Proposed Versus Current Approach to Estimate Precision and Bias for Gaseous Automated Methods for the Ambient Air Monitoring Program (L. Camalier, EPA)
- Introduction to the IMPROVE Program's New Interactive Web-based Data Validation Tools (L. DeBell, Colorado State University)
- The Role of QA in Determination of Effects of Shipping Procedures for PM2.5 Speciation Filters (D. Crumpler, EPA)

3:00 – 4:30 WEDNESDAY, APRIL 13TH

Topics in Environmental Data Operations (TEDO) (Salons A-C) *Chair: M. Kantz, EPA*

- Ethics in Environmental Operations: It's More Than Just Lab Data (A. Rosecrance, Laboratory Data Consultants, Inc.)
- QA/QC of a Project Involving Cooperative Agreements, IAGs, Agency Staff and Contracts to Conduct the Research (A. Batterman, EPA)
- Dealing with Fishy Data: A Look at Quality Management for the Great Lakes Fish Monitoring Program (E. Murphy, EPA)

Quality System Development (QSD) (Salon D) *Chair: A. Belle, EPA*

- Development of a QA Program for the State of California (B. van Buuren, Van Buuren Consulting, LLC)
- Integrating EPA Quality System Requirements with Program Office Needs for a Practical Approach to Assuring Adequate Data Quality to Support Decision Making (K. Boynton, EPA)
- Introducing Quality System Changes in Large Established Organizations (H. Ferguson, EPA)

Auditor Competence (AC) (Salons F-H) *Chair: K. Orr, EPA*

- Determining the Competence of Auditors (G. Johnson, EPA)

To Detect or Not Detect—What Is the Problem? (TDND) (Salon E) *Chair: J. Warren, EPA*

- A Bayesian Approach to Measurement Detection Limits (B. Venner)
- The Problem of Statistical Analysis with Nondetects Present (D. Helsel, USGS)
- Handling Nondetects Using Survival Anal.(D. Helsel, USGS)
- Assessing the Risk associated with Mercury: Using ReVA's Webtool to Compare Data, Assumptions and Models (E. Smith, EPA)

Ambient Air Session IV (Sierra 5&6) *Chair: M. Papp, EPA*

- Status and Changes in EPA Infrastructure for Bias Traceability to NIST (M. Shanis, EPA)
- Using the TTP Laboratory at Sites with Higher Sample Flow Demands (A. Teitz, EPA)

5:00 – 6:00 PM WEDNESDAY, APRIL 13TH

EPA SAS Users Group Meeting Contact: Ann Pitchford, EPA

8:30 – 10:00 THURSDAY, APRIL 14TH
Evaluating Environmental Data Quality (EEDQ) *(Salons A-C) Chair: M. Kantz, EPA*

- QA Documentation to Support the Collection of Secondary Data (J. O'Donnell, Tetra Tech, Inc.)
- Staged Electronic Data Deliverable: Overview and Status (A. Mudambi, EPA)
- Automated Metadata Reports for Geo-Spatial Analyses (R. Booher, INDUS Corporation)

Satellite Imagery QA (SI-QA) (Salon D) *Chair: M. Cusanelli, EPA*

- Satellite Imagery QA Concerns (G. Brilis and R. Lunetta, EPA)

Information Quality Perspectives (IQP) (Salons F-H) *Chair: J. Worthington, EPA*

- A Body of Knowledge for Information and Data Quality (J. Worthington, L. Romero Cedeno, EPA)
- Information as an Environmental Technology – Approaching Quality from a Different Angle (K. Hull, Neptune and Co.)

To Detect or Not Detect—What Is the Answer? (TDND) (Salon E) *Chair: A. Pitchford, EPA, Co-Chair: W. Puckett, EPA*

- Using Small Area Analysis Statistics to Estimate Asthma Prevalence in Census Tracts from the National Health Interview Survey (T. Brody, EPA)
- Logistical Regression and QLIM Using SAS Software (J. Bander, SAS)
- Bayesian Estimation of the Mean in the Presence of Nondetects (A. Khago, University of Nevada)

Ambient Air Workgroup Meeting (Sierra 5&6) *Contact: Mike Papp, EPA*
NOTE: This is an all-day, closed meeting.

10:30 – 12:00 THURSDAY, APRIL 14TH
Environmental Data Quality (EDQ) (Salons A-C) *Chair: V. Holloman, EPA*

- Assessing Environmental Data Using External Calibration Procedures (Y. Yang, CSC)
- Groundwater Well Design Affects Data Representativeness: A Case Study on Organotins (E. Popek, Weston Solutions)

Information Quality and Policy Frameworks (IQPF) (Salons F-H) *Chair: L. Doucet, EPA*

- Modeling Quality Management System Practices to an Organization's Performance Measures (J. Worthington, L. Romero Cedeño, EPA)
- Development of a QAPP for Agency's Portal (K. Orr, EPA)
- Discussion of Drivers and Emerging Issues, Including IT, That May Result in Revisions to EPA's Quality Order and Manual (R. Shafer, EPA)

Office of Water; Current Initiatives (OW) (Salon D) *Chair: D. Sims, EPA*

- Whole Effluent Toxicity--The Role of QA in Litigation (M. Kelly, EPA, H. McCarty, CSC)
- Review of Data from Method Validation Studies: Ensuring Results Are Useful Without Putting the Cart Before the Horse (W. Telliard, EPA, H. McCarty, CSC)
- Detection and Quantitation Concepts: Where Are We Now? (Telliard, Kelly, and McCarty)

Sampling Inside, Outside, and Under (SIOU) (Salon E) *Chair: J. Warren, EPA*

- VSP Software: Designs and Data Analyses for Sampling – Contaminated Buildings (B. Pulsipher, J. Wilson, Pacific Northwest National Laboratory , R. O. Gilbert)
- Incorporating Statistical Analysis for Site Assessment into a Geographic Information System (D. Reichhardt, MSE Technology Applications, Inc.)
- The OPP's Pesticide Data Program Environmental Indicator Project (P. Villanueva, EPA)

1:00 – 2:30 THURSDAY, APRIL 14TH

Information Management (Salons A-C) *Chair: C. Thoma, EPA*

- Achieve Information Management Objectives by Building and Implementing a Data Quality Strategy (F. Dravis, Firstlogic)

UFP Implementation (Salon D) *Chair: D. Sims, EPA*

- Implementing the Products of the Intergovernmental DQ Task Force: The UFP QAPP (R. Runyon, M. Carter, EPA)
- Measuring Performance: The UFP QAPP Manual (M. Carter, EPA, C. Rastatter, VERSAR)

Quality Systems Guidance and Training Developments (QSG) (Salons F-H) *Chair: M. Kantz, EPA*

- A Sampling and Analysis Plan Guidance for Wetlands Projects (D. Taylor, EPA)
- My Top Ten List of Important Things I Do as an EPA QA and Records Manager (T. Hughes, EPA)
- I'm Here---I'm Free----Use Me! Use Me!—Secondary Use of Data in Your Quality System (M. Kantz, EPA)

Innovative Environmental Analyses (IEA) (Salon E) *Chair: M. Conomos, EPA*

- Evaluation of Replication Methods between NHANES 1999-2000 and NHANES 2001-2002 (H. Allender, EPA)
- Assessment of the Relative Importance of the CrEAM Model's Metrics (A. Lubin, L. Lehrman, and M. White, EPA)
- Statistical Evaluation Plans for Compliance Monitoring Programs (R. Ellgas, Shaw Environmental, Inc.; J. Shaw, EMCON/OWT, Inc.)

Data Error Reduction by Automation throughout the Data Workflow Process

Arnold L. Gray, Ph.D., EarthSoft, Inc., 4141 Pine Forest Road, Cantonment, FL 32533

Abstract:

Efforts directed at establishing data quality such as data validation review can be rendered meaningless by errors that occur at other steps in the data management workflow process. Errors in field collection are often miss-entered into spreadsheets, data loaded improperly into the data repository, or uploading data to analytic applications are all prime sources of induced data error that can result in poor decision making by managers. This paper addresses the environmental data workflow process, areas susceptible to error induction, and solutions to these problems.

Introduction

While the importance of data quality is widely understood, it is often surprising to discover how many professionals fail to consider how the data with which they work fits in with data from sources outside of their particular specialty. The laboratory chemist maintains data check to be sure instrumentation is working correctly. Data validation involves a long series of checks to assure that results from the lab are meaningful. These data are then combined, however, with additional data sets that receive virtually no quality control coming from the field and entered into analytic systems—often incorrectly—and with no consistency control from one data load to the next. The net effect is high quality laboratory data mixed with poor quality field and other data that can render the data body worse than useless. It is one thing to have no data at all, but much worse to have data that leads to making incorrect decisions.

Data Workflow Process

In order to address the total data quality issue, it is important to look at the data workflow process. At each data acquisition, transcription, and application phase, there are pitfalls and pratfalls where substantial problems arise. All environmental data originates in the field. Environmental consultants collect field data, install field structures such as boreholes and wells taking note of observations made in the process. They collect samples to send off to the lab taking note of locations, depths, collection tools and procedures, and other relevant information.

Samples received by laboratories are accompanied by a chain of custody and a sample identification code that allow the results to be tied back to the field activity with which they are associated. The amount of field data received by laboratories is supposed to be intentionally limited to prevent the lab from being able to defeat QA/QC procedures. This allows the lab to run a truly blind analysis of initial and duplicate samples. These limitations, however, are very often overlooked.

Data from the field and from the laboratory are transferred for communication either in paper format or as electronic data deliverables (EDDs). From these, consultants produce reports and load environmental data into analytic tools for analysis (Figure 1). These analyses are generally brought together in a report and used for decision making purposes either by corporations or regulatory agencies at state or federal levels.

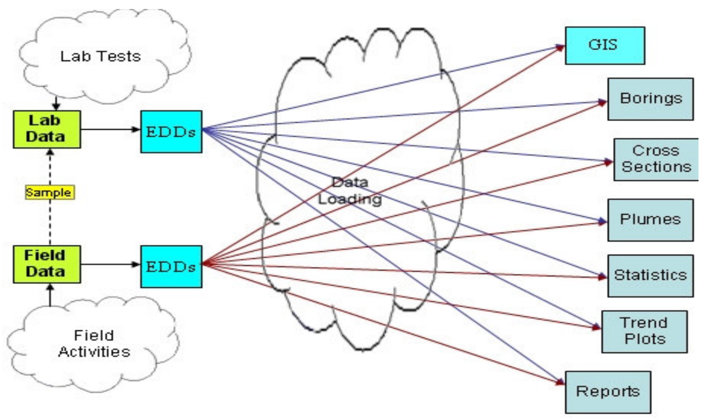


Figure 1. Native Data Workflow. Lab and field data are produced and handled separately, often involving dozens of spreadsheets.

What is important to note is that the two primary data streams -- field data and laboratory data -- are maintained separately throughout the process. At almost every phase there are opportunities for data corruption to occur. These "opportunities" can be thought of as data sinks; places where data quality is lost, sometimes irreparably. It is important to understand where the sinks are located and their cause. This is not a simple task. If it were, the sinks would no longer be with us. But they do persist despite the fact that we repeatedly pay the price for our bad data in lost time, financial inefficiencies, and poor decision making affecting human health and environment.

Field Data Errors

Data Omissions. The first set of data errors that are produced come from failure to record needed items while in the field. In sampling for metals, for instance, laboratory results are easily rendered meaningless if data on field filtering is not noted. There are hundreds of data elements that need to be recorded in the field. Those left out may not be noticed until data are analyzed, or worse, may not be detected at all.

One of the best ways to eliminate data omissions is the development data entry forms. A number of these forms exist; many, however, have notable shortcomings. Initially, field personnel turned to handheld PDAs as lightweight tools for electronic data entry. These have demonstrated several shortcomings. First, they are often difficult to read in direct sunlight. Second, there is inadequate landscape on the screen to permit viewing of many data fields. This can lead to omission errors as unseen fields on the PDA may not get filled in. In addition, the most commonly available PDAs are fragile and not suited to field conditions while field hardened devices are expensive in the extreme.

Tablet devices overcome a number of these problems although not all. However, a data entry form based on a tablet format can also be used within normal laptop computer, or, can be printed out on paper, brought to the field and filled out, and return to the office for very simple data entry into a data form that is identical in appearance (Figure 2). Having this variety of options makes a tablet format versatile and reliable.

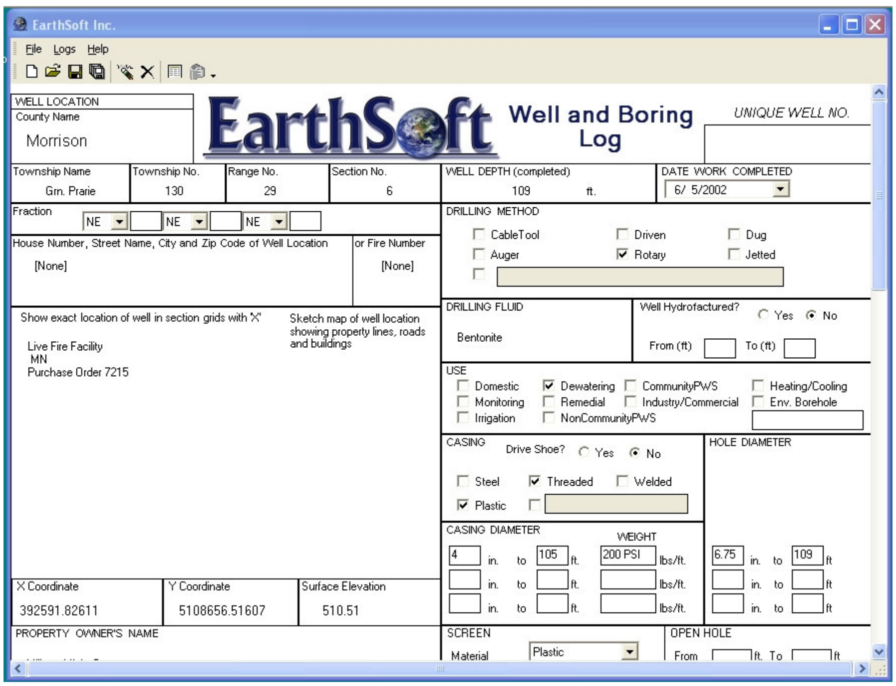


Figure 2. Detail from data collection form. This computerized data entry form emulates a paper format providing a basic level of comfort for field workers.

Transcription Errors. A much more important error sink involves data transcription. In order to get data from the field into an analysis application, data must be transcribed from field notes into spreadsheets to be loaded into the specific application. The task, which is not trivial, is to get all of the data elements not only in the correct cells, but into the proper spreadsheet. For most field crew members this can be a daunting task.

Again, the data entry form can make the difference. EarthSoft's intelligent data entry forms (IDEFs) take the data entered into the form and automatically transfers the data to the appropriate electronic data deliverable file. In this case, the automation process assures that the data entered into the form winds up in the correct place for proper data loading.

It should be noted that a properly designed data entry form shies away from computer gadget wizardry. Field crews are generally ill-at-ease with computer-based systems and their complexities. For the EarthSoft IDEFs, a simple paper format was chosen with simple fill-in's, pull-down's, and selection buttons. The comfort level associated with a paper-based format contributes to the success of the data entry and transcription process.

Field Data Integration with Lab EDDs. Note in Figure 1 that lab data and field data follow independent paths from their source to their end use. Errors can emerge if data from two sources fall out of synchronization. A lab data result attached to the wrong location (a field recording) can make the data display in a GIS system suggest a different remedy strategy then the correct data would have provided. EarthSoft's EQuIS Data Processor (EDP) is designed to check for errors within and between EDD sets (Figure 3). Errors that can be identified in this way include inconsistencies in terminology, sample submissions for which there are no data, data for which there appear to be no samples, impossible values, and other such items that may go unnoticed checking EDDs manually and individually. The task of this tool is to tie to every needle-in-the-haystack, a neon sign. Automation does not come without a price. In working successfully with EDDs, that price is standardization. Valid values need to be assigned and adhered to in order for data quality checking to occur. Once instituted, however, standardization yields huge benefits in establishing and maintaining data quality.

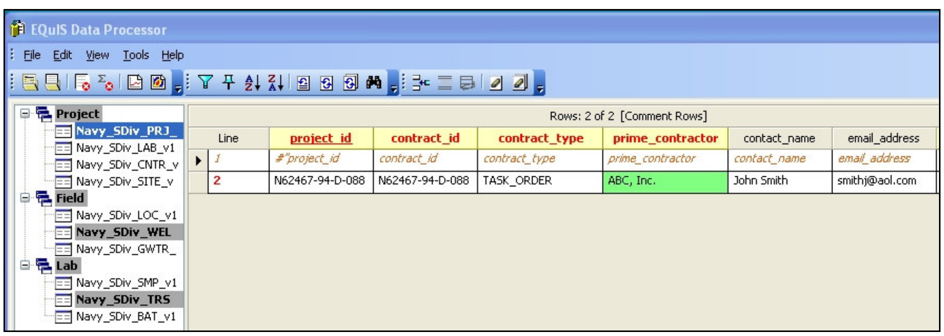


Figure 3. Automated error identification. The objective of the data quality checking tool is to find errors of all sorts and make them difficult to miss rather than difficult to find.

Data Loading

In Figure 1, data produced in the field and the laboratory have to be loaded into the various data analytic tools individually. The data file that can be loaded into Surfer, for example, cannot be used to load the data into the GIS and vice versa. Even when data are properly loaded into spreadsheets, they must be formatted in accordance with the rules of the application being used. Many applications mean many formats. Formatting data many times over for different applications is another data error sink. Data formatting usually involves cutting and pasting within spreadsheets and over time, errors are virtually inevitable.

The EQuIS data warehouse was designed in large part to address these problems. Data loaded once into EQuIS can be seamlessly transferred into a wide range of environmental data analytic applications. As it is an automated process, data transfers happen instantly and without error.

Automating data management again comes at the price of standardization. A properly designed data warehouse includes a well-thought-out set of valid values, solid relationship structures within the database, and tools to identify where relationships are not in place and valid values violated. This most basic level of quality assurance must be addressed if the automated system is to function properly. Once established, however, virtual magic can be accomplished.

In EQuIS 5, EarthSoft's newest release, EQuIS Data Processor functions are fully automated so that the user is never required to load data by hand. Data sets are delivered, automatically checked, and when correct automatically loaded into the data warehouse. When not correct, error logs are instantly generated and e-mailed to the submitter with an EDD rejection notice. The submitter is then required to repair the EDDs and resubmit.

A standalone version of the EDP can also be made available to field crews and laboratories so that data checking can occur before the data submission process begins. Using this combination of tools, a double closed-loop checking process is created establishing higher levels of data quality that have previously been possible (Figure 4). In this instance, the standalone and automated tools are written with the same code so that an error detected in one will be identically identified in the other. Accepted EDDs can be counted on for data accuracy and to function properly in the database and to be appropriately recorded in the document management system.

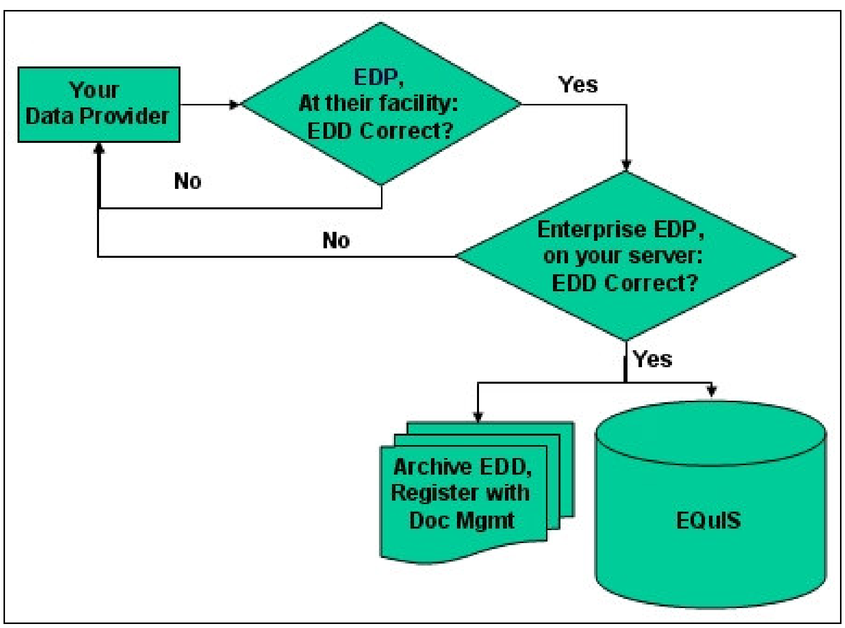


Figure 4. Double closed-loop data checking. By checking data quality locally before data submission, data providers are free to repair data and make clean submissions. The automated system check makes sure no errors make it through the cracks.

Data Validation

For most attendees at this conference, data validation is their forte. For a large part of the data management universe, however, efforts at data validation often fail. Consultants and regulatory agencies under tremendous time constraints must often skip validation procedures. Some firms and agencies lack the ability to validate data altogether. The costs of these oversights are unknown but are probably staggering in scope.

There are a few facts that limit the potential for automated data validation. The most important of these is that data validation is a human judgment process and cannot be duplicated by a computer. Let's imagine a data set for which a holding time of 60 days for some analytes has been established. If the sample is analyzed on day 61, is it truly less valuable than had it been analyzed the day prior. The answer depends on several variables. If the data is being submitted to a regulatory agency as part of a formal investigation, then probably yes. If the data are being used internally in an effort to understand the extent of a contamination problem, then absolutely not. Data always exists within a specific context and the validator's answer can vary on that basis.

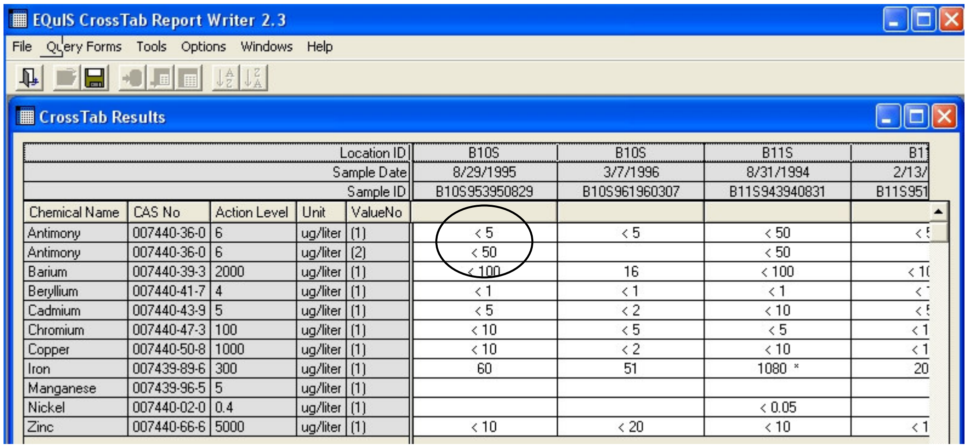
But are their parts or aspects of the data validation process that can be enhanced through automation? The answer here is a resounding yes. Even for the most fastidious among us, looking through volume after volume of analytic data for surrogate results that are out of range followed by finding the normal environmental samples associated with the surrogate failure and applying the proper qualifier to that result is a somewhat less than rewarding task. It is boring, eyes grow tired and errors can be made, and it is now unnecessary. This sort of task is exactly what computers do best and infinitely better than humans.

Laboratory Data Consultants, Inc., for example, has written a tool that looks through volumes of data identifying errors in reporting limits, missed holding times, surrogates out of range, problems with method blanks and dupes, matrix spikes and dupe % recoveries, and lab control sample issues a matter of moments rather than days. A major part -- the grunt work part -- of the data validation process can be successfully automated leading to higher quality validation in less time and at a lesser cost. This tool does not replace data validation or data validators. What it does is free more time for analysis of what the data means, adjustments that can be made to make the data usable, and other such tasks that require a pair of hands, a good set of eyes, and a well-developed human skill set.

Data Loading to Analytic Applications

Data loading into analytic applications is where the rubber hits the road for environmental data. The entire purpose of data validation and data quality objectives is to produce correct and exact data that can be analyzed, assessed, and from that, decisions made.

Analytic applications can also be used to check data quality. In the cross tab report below (Figure 5), we see that a duplicate record exists for antimony with one value at 5 ug/l and one at 50 ug/l. Since the regulatory limit is identified at 6 ug/l, the correct value to use is an important issue to be resolved.



				Location ID	B10S	B10S	B11S	B11
				Sample Date	8/29/1995	3/7/1996	8/31/1994	2/13/
				Sample ID	B10S953950829	B10S961960307	B11S943940831	B11S951
Chemical Name	CAS No	Action Level	Unit	ValueNo				
Antimony	007440-36-0	6	ug/liter	(1)	< 5	< 5	< 50	<
Antimony	007440-36-0	6	ug/liter	(2)	< 50		< 50	
Barium	007440-39-3	2000	ug/liter	(1)	< 100	16	< 100	< 1
Beryllium	007440-41-7	4	ug/liter	(1)	< 1	< 1	< 1	<
Cadmium	007440-43-9	5	ug/liter	(1)	< 5	< 2	< 10	<
Chromium	007440-47-3	100	ug/liter	(1)	< 10	< 5	< 5	< 1
Copper	007440-50-8	1000	ug/liter	(1)	< 10	< 2	< 10	< 1
Iron	007439-89-6	300	ug/liter	(1)	60	51	1080 *	20
Manganese	007439-96-5	5	ug/liter	(1)				
Nickel	007440-02-0	0.4	ug/liter	(1)			< 0.05	
Zinc	007440-66-6	5000	ug/liter	(1)	< 10	< 20	< 10	< 1

Figure 5. Cross tabulated report. One of many analytic tools that can be employed to detect data errors after data checking and validation efforts are complete.

In this particular case, examination of the data revealed that a split sample was analyzed using two different test methods with different minimum detection limits, one set at 5 ug/l and the other at 50 ug/l. Here, it is a simple matter that the method using the 50 ug/l MDL is inadequate and should either be qualified as such or eliminated from the data set entirely.

Other tools may also be used to identified in errors. Trend plots can be used to identify outliers or other data trends that simply don't make sense. Comparisons made with visualization tools can identify where data at a specific location is wildly out of sorts with surrounding data. While this can also indicate a serious disruption in a localized area, the data should also be reviewed for accuracy.

As discussed earlier, use of a data warehouse that automates data population into third-party analytic tools reduces the likelihood that errors in data loading will occur. Because results in such a system can be generated rapidly, it becomes possible to run an array of checks using third-party applications to seek out errors.

The EQuIS for ArcGIS interface provides an example of the benefits that come from system integration. In normal use, GIS practitioners load data sets from the field and from the laboratory normally linking them only at the most basic level so that result values are associated with the location. When the EQuIS for ArcGIS interface is present and an ArcGIS project is opened that contains data in EQuIS, the data load is much more sophisticated and advanced. EQuIS data exists in a highly relational database. When the EQuIS data is loaded into ArcGIS automatically, it not only passes the data into the appropriate ArcGIS tables, but automatically creates all of the joins and relates in the ArcGIS that are associated with relationship structure in the EQuIS database. In addition, required metadata fields are also populated so that the quality of the data in the GIS can be evaluated at a later time. These additional steps allow for far more complex querying in ArcGIS that is possible with a basic manual data load. Moreover, the data are always entered correctly and without error.

The key to this discussion is that the most carefully validated data can be ruined if transcribed into an analysis tool improperly. Additional data checks are necessary to maintain the quality of data once it has been validated. Failure to take the steps can result in data erroneous believed to be of the highest quality leading decision makers to wrong conclusions.

Application Integration

Synchronicity. A follow-up benefit to using an advanced data warehouse such as EQuIS can be seen by the ability to integrate results from different applications in a visualization to explain a glance at which would take days of poring over numeric results to identify. In Figure 6, ArcScene is used to visualize the results obtained from data in an EQuIS database. A pathway was generated in ArcMap identifying the path for a fence diagram. From this, data was sent via the EQuIS for ArcGIS interface to RockWorks (by RockWare) to produce a three-dimensional fence diagram saved as a 3-D shape file and automatically displayed in a 3-D scene. EVS (by CTech Development) produce a contaminant plume in the same way, again inserted into the 3-D scene. Monitoring well construction diagrams together with soil profiles were produced using ESRI's multi-patch geometry feature. Together, they provide a powerful image of the subterranean geology and chemistry features found at this facility.

A caveat is in order here. When an image of this sort is produced, it tends to takes on a life of its own. The power of the technology that produces such images can hardly be questioned. And therein lies the danger. Images produced with bad data are as beautiful and powerful and persuasive as are images produced with the good data. Moreover, by simple inspection it is usually impossible to tell the difference. Consequently, data quality -- and this does not mean simply "validated" data, but data quality established and maintained through a long sequence of data manipulations and events -- is critical to the data quality process.

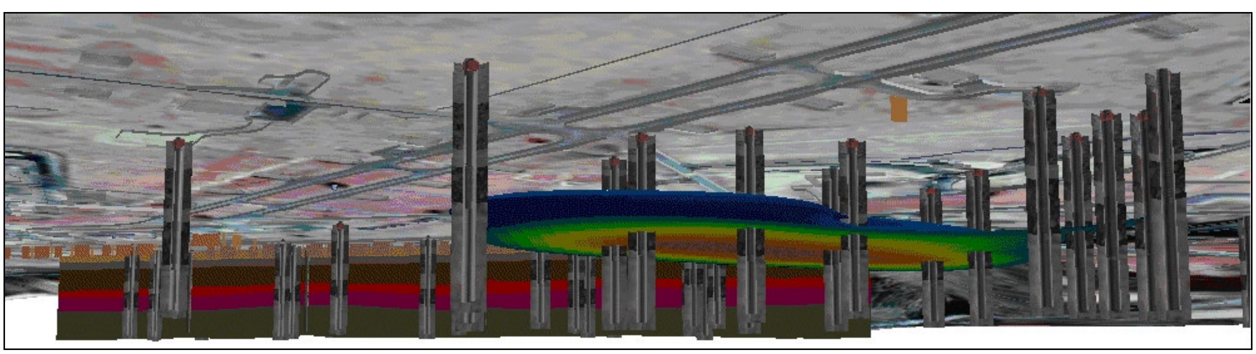


Figure 6. Application Integration. This visualization employs output from a number of environmental data analytic tools to provide a view of what exists below the surface at a contaminated site. In the ArcScene application, you would be able to navigate around in the view to examine exacting details.

Conclusion.

One of the most basic concepts we cover early in our science education is the difference between and the importance of necessary and sufficient conditions. To achieve data quality, validation is a necessary component but it is not by itself sufficient to establish data quality. There are many more necessary components. What the potential for data automation has created in our industry for the first time is the combination of necessary conditions to establish and substantiate that sufficient conditions have been achieved.

Data quality is far more likely to be achieved and maintained in a fully automated data environment using proper data collection tools, data checking tools and data validation assistance combined with a data warehouse that provides seamless integration of data to analytic applications. Automated data collection tools help eliminate a major sink for data quality. That data checking can occur directly from the collection tool's output provides field crews the opportunity to take measurements they might have missed over the course of a day or correct observations that are still fresh in their memories or available on scraps of paper.

To be most effective, data checking tools must be used as close to the source of error as possible so that corrections can be made with the least amount of lost time or effort. If laboratory errors are caught at the laboratory immediately from the LIMS output, it is easier to repair that data. Because the errors can be identified within moments, in the worst-case, it may be possible to rerun effected samples. Finding the errors months later leads to a far more expensive course of action.

Keeping data straight in hundreds of individual spreadsheets is an unlikely prospect. Use of a data warehouse keeps all data together in a single instrument reducing the opportunity for misplaced or destroyed data sets to be lost for future use (Figure 7). Automated population of data from the warehouse to analytic applications eliminates a major data quality sink. In addition, it allows data analyses from various applications to be used together in ways that were previously either extremely difficult or impossible.

Automation capabilities with today's technology make it possible for the first time in our history in this industry to truly establish and maintain data quality across the entire data workflow process. It becomes our responsibility as data quality professionals to achieve the highest possible levels of data quality possible. Continued development in this field will provide greater opportunities for data quality into the future. Movement to a total data quality approach is now possible and there are no longer acceptable reasons to accept less.

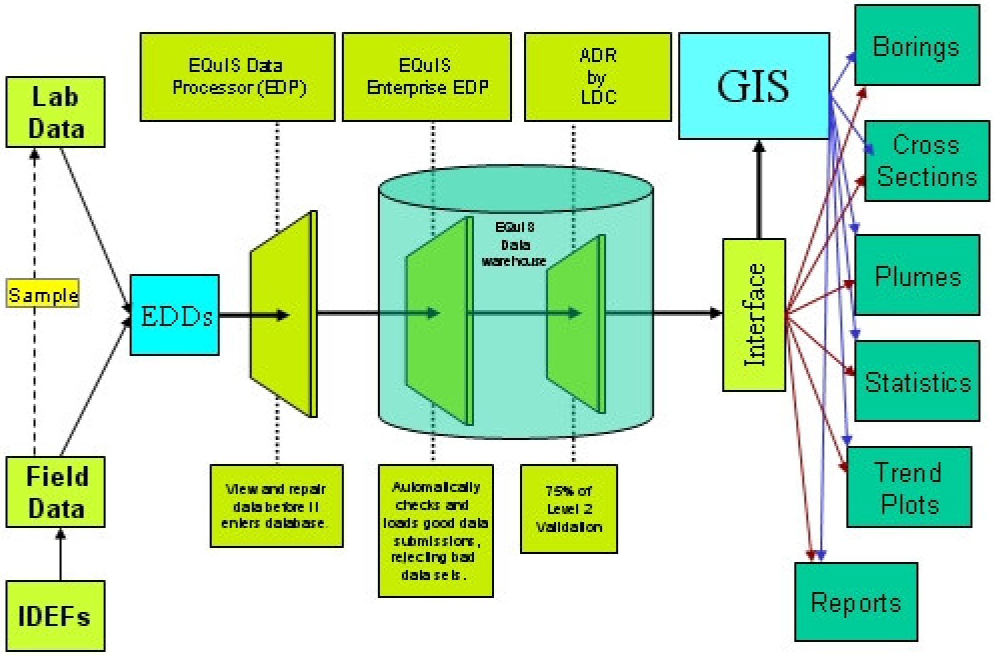


Figure 7. Fully automated and integrated data workflow process.

Analytical Approaches to Meeting New Notification Levels for Organic Contaminants in California

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The Drinking Water Program (DWP) of the Department of Health Services (DHS) establishes Maximum Contaminant Levels (MCL) for contaminants based on their significant risk factors affecting the public health of Californians. The process is lengthy and tedious, and is further complicated by ever increasing scientific knowledge of chemical toxicants. Data reported by water purveyors sometimes reveal the presence of unregulated chemicals in drinking water at levels that may affect the public health of Californians. Consequently, Public Health officials are faced with the burden of responding to these findings with a strategy for protecting human health. The DWP in collaboration with the laboratory assumes the responsibility of developing and validating methods suitable to measure chemicals at these new levels. Finally, in its response to these findings, a Notification Levels (NL) is established. Setting NL serves as an interim measure in the final establishment of the State MCLs. The approach is illustrated using 1,2,3-Trichloropropane (TCP) as an example.

The Drinking Water Program (DWP) of the Department of Health Services (DHS) plays an active role in protecting the public from exposure to chemical contaminants from drinking water consumption. The Section 116365(a) of California Health and Safety Code[1] mandates the DWP to establish Maximum Contaminant Levels (MCL) for contaminants based on their significant risk factors affecting the public health of Californians. Essentially, the process is initiated after receiving the Public Health Goals (PHG) from the CAEPA's Office of Environmental Health Hazard Assessment (OEHHA). After receiving PHGs the program selects possible draft levels of MCL concentrations for evaluation. The evaluation process is fairly complicated and lengthy because it needs to consider population exposure levels at different draft levels of MCLs along with cost considerations for monitoring at those levels. Once a determination is made, the evaluation process moves to the next stage where identification of treatment technologies and their associated costs are finalized. At the final stages of the review process thorough consideration is given to determine a good balance between the cost and health risk minimization in order to select a proposed MCL out of alternate draft MCLs considered.
Table **1** shows MCLs of some common contaminants.

The above process of establishing MCLs in California is very similar to the one used by USEPA. If the USEPA has already established the MCL for any contaminant, California simply adopts the Federal standard by regulations. However, for certain waters, such as ground waters in agricultural areas, additional chemical contaminants are known to occur. For such waters, adopting and enforcing the federal MCLs alone does not protect the public from exposure to other contaminants that may cause adverse health effects. Under those circumstances, the DWP makes an extra effort to establish a precautionary level known as the Notification Level (NL).

Table 1. MCLs of Some Common Contaminants[2,3]

Contaminant	**MCL (μg/L) California**	**MCL ((μg/L) Federal**
Benzene	1.0	5.0
Chromium	50	100
Freon 11	150	-
Methyl *tert*-butylether (MTBE)	5.0	-
Vinyl chloride	0.50	2.0

There are three main drivers for this effort; (a) the presence of a well established monitoring program here in California that captures findings reported by water systems, (b) ever increasing scientific knowledge of chemical toxicants in relation to human health that suggests toxicity levels need to be updated periodically, and (c) advances in measurement techniques that have significantly lowered detection capability that allows the DWP's Sanitation and Radiation Laboratory (SRL) to develop and validate methods to measure these new contaminants at lower levels. California's DWP collects data reported by water purveyors. On occasion, these data reveal the presence of unregulated chemicals in drinking water. Public health significance of these chemicals at such levels is unknown. This exercise is clearly illustrated by findings of 1,2,3-trichloropropane (1,2,3-TCP, an unregulated chemical) in water systems. 1,2,3-TCP is used industrially as a solvent and paint remover, and in agricultural areas as a fumigant in formulations with *cis*- and *trans*-1,3-dichloropropenes. Between 1989 and late 1990s, less than 20 detections of this chemical were reported. However, between late 1990s and end of 2004, 81 water systems in 16 counties have reported the presence of this chemical at measurable levels with the number of detections being more than 200. This trend is also observed with respect to other contaminants such as N-nitrosodimethylamine (NDMA) and perchlorate.

As a result of wide spread occurrences of these contaminants at levels that may cause adverse health effects, Public Health officials are faced with the burden of responding to these findings with a strategy for protecting human health. The main concern here is to protect the public health based on newer scientific data, but at the same time without unduly burdening the water purveyors. Typically, DWP requests OEHHA to evaluate existing data for adverse health effects. The DWP in collaboration with the laboratory assumes the responsibility of developing and validating methods suitable for measuring chemicals at these new levels. Finally, DWP establishes NL, as an interim step in its response to these findings. If the water systems contain any contaminant above set NL, certain requirements and recommendations may apply merely as a precautionary measure. For 1,2,3-TCP the NL was set at 5 ng/L (parts per trillion) or 0.005 μg/L.

SRL is tasked with the responsibility of developing and validating methods that can achieve these new NLs. The laboratory begins the method development process by reviewing existing methods. In this case, EPA methods 502.2, 504.1, 524.2 and 551.1 were found to be capable of measuring 1,2,3-TCP. However, as shown in the Table 2, none of these methods measures down to the low ng/L level range.

Table 2. Detection Levels

Method	Volume Extracted (mL)	Detection Levels (µg/L)
502.2	35	-
504.1	35	0.02
524.2	35	0.32
551.1	50	0.008

Internal DWP audits reveal that analytical measurements performed at levels close to NL using the above methods have various deficiencies. Although by using prescribed methods an acceptable signal to noise ratio may be achieved, on occasion, factors such as matrix effects, co-elution with non-target analytes tend to introduce a degree of uncertainty to the reliability of the findings. This is because conventional identification criteria (retention times, molecular ions) do not provide conclusive information. One approach to resolving these sample-to-sample variations is by employing independent confirmation methods or making major modifications to existing methods.

In recent years our laboratory has made attempts to address them by (a) modifying existing EPA methods to improve sensitivity and validating (b) adopting time efficient and waste minimizing extraction procedures, (c) taking advantage of emerging analytical techniques and state of the art instrumentation to reaffirm the accuracy of results. Laboratory experiments are always conducted within the framework of the acceptable method criteria, thereby preserving the essential elements of the approved method.

As mentioned earlier, once SRL has undertaken the task of reviewing existing methods or new methods for applicability, avenues to improve method sensitivity are examined. A reasonable calibration range is established following a set of preliminary experiments designed to establish refined Method Detection Levels (MDL) and Reporting Levels (RL). The method is subjected to an initial demonstration of capability (IDC). The IDC includes verification of calibration ranges, laboratory spike recoveries, laboratory reagent blanks, precision, accuracy, and MDL studies. A set of samples from known areas of contamination (example: agricultural areas of the central valley) is analyzed to document reliability of the MDL and RL. Based on these data a Reporting Level is established, generally at 3 to 5 times the MDL. Although initial method modification and validation are carried by an analyst under direction from the Supervisor and the Quality Assurance Officer's guidance, the final method recommendation is subjected to method ruggedness and data reliability checks. Testing ruggedness and reliability of the method is achieved when the method can be performed by multiple analysts in multiple laboratories.

Table 3 shows the distribution of 1,2,3-TCP detections as of December 01, 2004 in individual counties in California. Clearly, the counties with heavy agricultural industry are experiencing the bulk of the problem.

Table 4 shows the concentration distribution in relation to the number of detections observed from the same pool of data as above. The highest 1,2,3-TCP level reported to date is 57 µg/L, in Los Angeles County. Following the availability of sufficient data showing that it has carcinogenic properties,[4] in 1999, the State of California moved 1,2,3-TCP to its list of chemicals known to cause cancer in humans. Later it was added to the list of "Unregulated Chemicals" required monitoring with Detection Limit for the purpose of Reporting (DLR) set at 5ng/L. The action prompted the laboratories to include 1,2,3-TCP along with other volatile target analytes.

Table 3. Reported 1,2,3-TCP Detections[5]

County	No. of Sources	No. of Systems
Kern	93	17
Los Angeles	35	14
Fresno	26	7
Tulare	23	5
San Bernardino	21	6
Merced	17	8
Monterey	10	3
San Joaquin	8	2
Riverside	7	5
San Mateo	7	2
San Diego	6	2
Stanislaus	6	5
Sacramento	2	2
Kings	1	1
Madera	1	1
Solano	1	1
Total	**264**	**81**

Table 4. Concentration Distribution of 1,2,3-TCP

Concentration (μg/L)	No. of Sources
> 50	1
5.1 - 50	4
0.51 – 5.0	17
0.051 – 0.50	96
0.0051 – 0.05	144
<0.0051	2
Total	**264**

In the following paragraphs we will illustrate our experience in developing and validating method(s) suitable to measure 1,2,3-TCP at 5ng/L as the RL. The two methods that are capable of analyzing 1,2,3-TCP in water, with quantification at DLR of 5ng/L are, purge and trap – isotope dilution GC/MS (method 1624) and semi-volatile extraction followed by isotope dilution GC/MS (method 1625). Taking advantage of excellent sensitivity of the Electron Capture Detector (ECD), some laboratories analyze 1,2,3-TCP purely by GC (methods 504.1 and 551.1) and meet the DLR mentioned above. But those samples with high Total Dissolved Solids (TDS), Total Organic Carbon (TOC) and/or volatile contents need MS confirmation. Method 504.1, although a time and solvent saving microextraction procedure, contributes to high background due to contamination arising from other non-target analytes. Therefore, quantitation at low levels yields poor Relative Percent Deviations (RPD). On the other hand, method 1624 seems to produce less background with acceptable RPDs. Multiple samples from several sites in Southern California were analyzed in our laboratories using purge and trap GC/ITD and purge and trap GC/MSD using isotopic internal standards (method 1624). Results obtained from that study are shown in Table 5, and also illustrated in Figure 1. RPDs tend to fluctuation at low concentrations, but become more stable as the concentration increases.

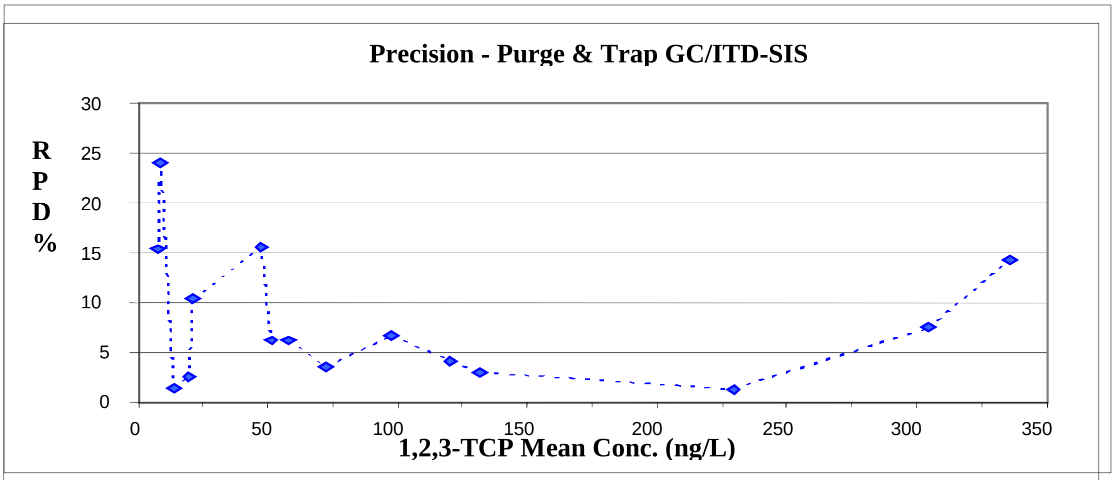
For the purpose of comparing different detectors for sensitivity and reliability, numerous samples were analyzed using two different detectors: (a) ion trap detector in Selective Ion Storage (SIS) mode, and (b) mass selective detector in Single Ion Monitoring (SIM) mode. The results, as summarized in Figure 2, shows good correlation between the two detection types. To evaluate the performance of the two methods, purge and trap-GC/MS (method 1624) and semi-volatile extraction-GC/MS (method 1625), samples collected from several sites in Southern California were analyzed: GC/MS analysis following semi-volatile extraction procedure was carried out using the ion trap, whereas the purge and trap data were collected using both ion trap and the mass selective detectors. Both methods produced comparable results, and inter-lab comparison gave a sense of comfort in the detectability of 1,2,3-TCP in the unprecedented ppt range. In spite of different experimental parameter variations for the different instrument systems, the DLR was limited to 5ng/L (ppt). The method sensitivity and accuracy was improved by utilization of isotopic internal standards. Quantitation of the most abundant ion in relation to its isotopic counterpart has several advantages. Since the isotopic standard is added to the sample prior to extraction, any analyte losses incurred during extraction is self-compensated. Since the analysis is focused around only a few ions, most matrix interferences can be minimized.

The next challenge for the DWP was to make a community of commercial labs capable of these low measurements available to the water purveyors. This task was achieved with the support of the Environmental Laboratory Accreditation Program (ELAP). ELAP relies on an interim certification process that involves, the receipt of an application/fee, site inspection and successful participation in a performance evaluation program. Once a set of commercial labs capable of measuring 1,2,3-TCP at 5ng/L is established, DWP sets the NL at that level. Although not ideal from a data quality view point, that was the best achievable at the time. Since both the DLR and the NL are the same (5 ng/L) one could always question the validity and reliability of the data near the NL. Therefore it was necessary to investigate method improvement in order to achieve DLRs well below the NL of 5.0 ng/L.

Table 5. Levels of 1,2,3-TCP from Several Wells in Southern California

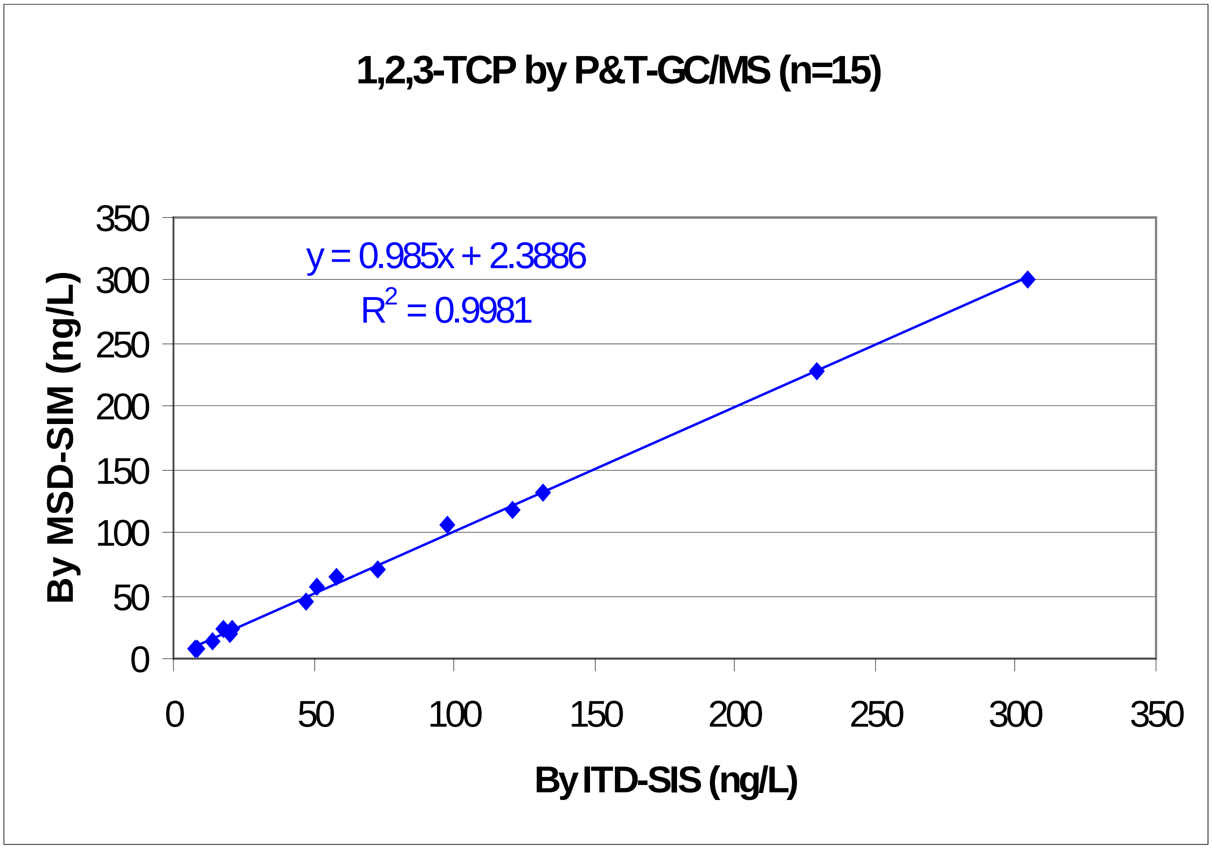
Location	**Sample Type**	**Mean (ng/L)**	**RPD (%)**
Los Angeles	Raw groundwater, drinking	7.80	15
Los Angeles	Raw groundwater, drinking	8.75	24
Manon Manor	Raw groundwater	13.7	1.5
Shafter	Raw groundwater	19.8	2.5
Burbank	WTP, raw groundwater	21.1	10
Los Angeles	Raw groundwater, drinking	47.6	16
Los Angeles	Raw groundwater, drinking	51.3	6.2
Burbank	WTP, raw groundwater	57.9	6.2
Shafter	Raw groundwater	72.6	3.6
Shafter	Raw groundwater	97.7	6.8
Shafter	Raw groundwater	121	4.1
Shafter	Raw groundwater	132	3.0
Shafter	Raw groundwater	230	1.3
San Joaquin	Raw groundwater	305	7.6
Fresno	Raw groundwater	336	14
		Mean RPD %)	**8.2**

Figure 1



Precision - Purge & Trap GC/ITD-SIS
RPD%
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
1,2,3-TCP Mean Conc. (ng/L)

Figure 2



Finally, the sensitivity can be further improved by advancing mass spectrometer measurements from low resolution to high resolution. The high resolution mass spectrometer operates with a reference compound constantly bleeding into the ion source. This feature enables the instrument to accurately assign the mass of any fragment ion by comparing with the reference compound. In general, fragments with accurately assigned mass units are unique, and can be related to their parent ions without any ambiguity. Therefore, interferences can be eliminated even in heavily contaminated samples. Analysis of well water from several agricultural areas in Southern California shows that of 1,2,3-TCP can be quantitated in levels as low as 1 ng/L (ppt). The analysis utilized samples prepared by quick and solvent saving micro-extraction procedure. Therefore, conclusive results from many samples contaminated at ultra low levels can be obtained within a short time period. However, a major disadvantage is the high capital cost of a high resolution GC/MS system. Studies on the applications of accurate mass analysis of several target and non-target analytes are currently in progress in our laboratory.

References

1. Health and Safety Code, 116365(a) can be viewed under State of California Official website.
2. Quality Assurance Project Plan, Division of Drinking Water and Environmental Management, Sanitation and Radiation Laboratory Branch, Rev. 5, July 30, 2004.
3. http://www.epa.gov/safewater/mcl.html#mcls.
4. USEPA, 1997. Health Effects Advisory Summary Tables, 1997 Update, EPA-540-R-97-036.
5. Department of Health services, Drinking Water Program guidelines on Notification Levels for 1,23-Trichloropropane, December 9, 2004 update available at the Drinking Water Program website.

Streamlining Data Management and Communications for the Former Walker AFB Project

Presented by Richard M. Amano, Principal Chemist, Laboratory Data Consultants, 7750 El Camino Real, Suite 2L, Carlsbad, California 92009, Brian Jordan, U.S. Army Corps of Engineers, Albuquerque District, 85 Dam Crest Road, Pena Blanca, NM 87041

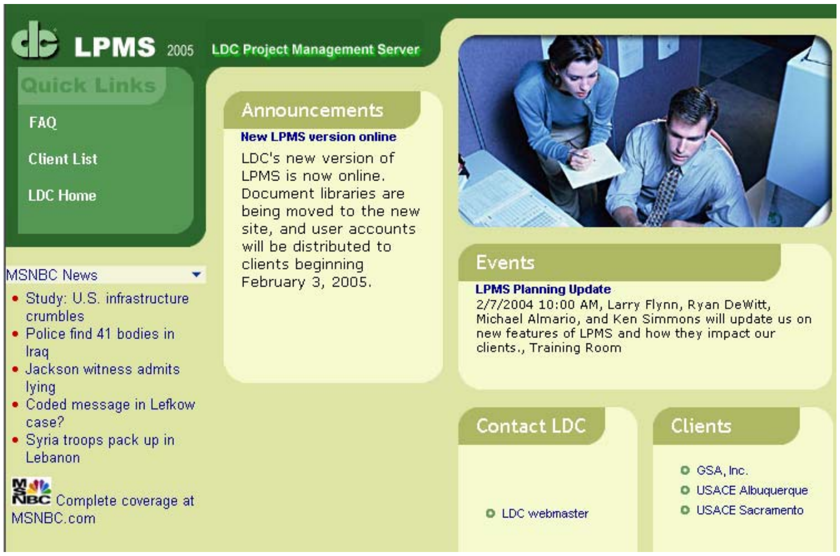
Introduction

This presentation is an overview of the Web-based project management system used for the streamlining of document management and communications for the Army Corps' Former Walker AFB project. Initially, the project was faced with dealing with many contractors, regulators, Army Corps staff, and the public in executing environmental assessments and monitoring for the site. Upon determining the requirements, the Army Corps' implemented the LDC Project Management System (LPMS). The features of the system include security for various levels of users, automated e-mail alerts, audit trail for document handling, ability to post project documents, aerial photographs, GIS overlays, contact lists, project schedules, calendars, bulletin boards, and correspondence. As discussed above, project documents include QAPPs, Field Sampling Plans, Health and Safety Manuals, Work Plans, and Standard Operating Procedures. These documents can be accessed for editing, reviewing, or approving. The system is password protected with different levels of access dependant upon the password security.

The presentation will discuss how the project team used the system features to improve project document sharing, communication, and save costs in the process. The system also has the unique ability to handle sophisticated DjVu compressed files for easier use over the Internet.

Opening Web Screen

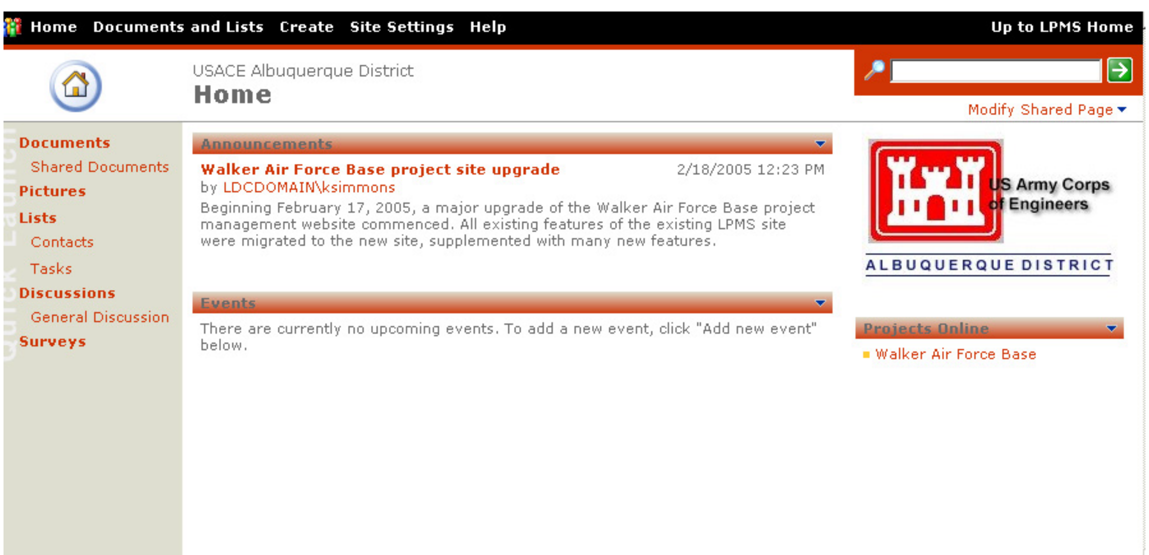
The LDC Project Management Server (LPMS) allows a user to access many projects within a click of a button. Under the client section, the Army Corps Albuquerque has a folder with all Albuquerque projects sites. See screen Image No. 1.



Screen Image No. 1, LPMS Opening Page

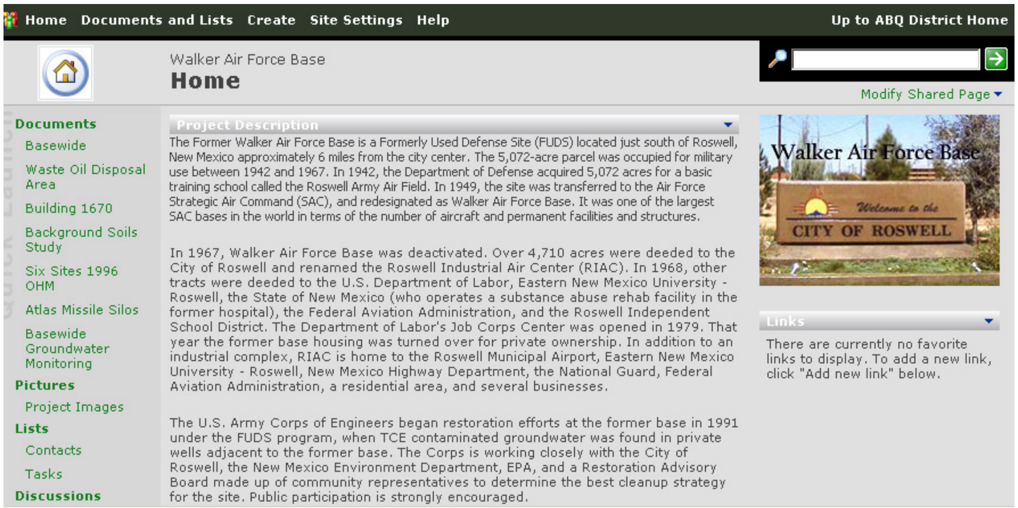
Army Corps Albuquerque District Home Page

The second layer in LPMS is the home page for the Army Corps Albuquerque District. This page will list all projects in which a document collaboration site has been established. See Screen Image No. 2 below.



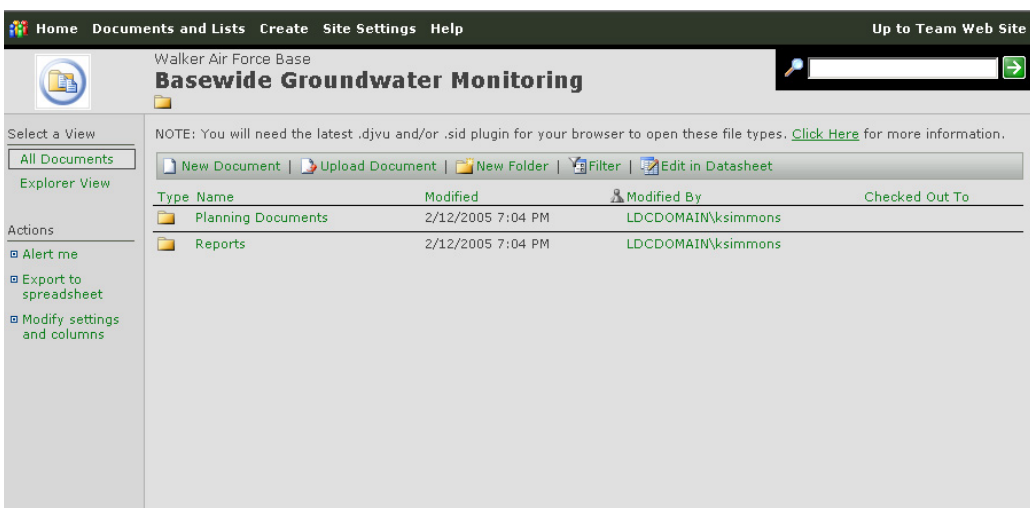
Screen Image No. 2, USACE Albuquerque LPMS
General Walker AFB Information

The next layer provides the user with general project information and access to all projects shared documents. See Image No. 3 below.



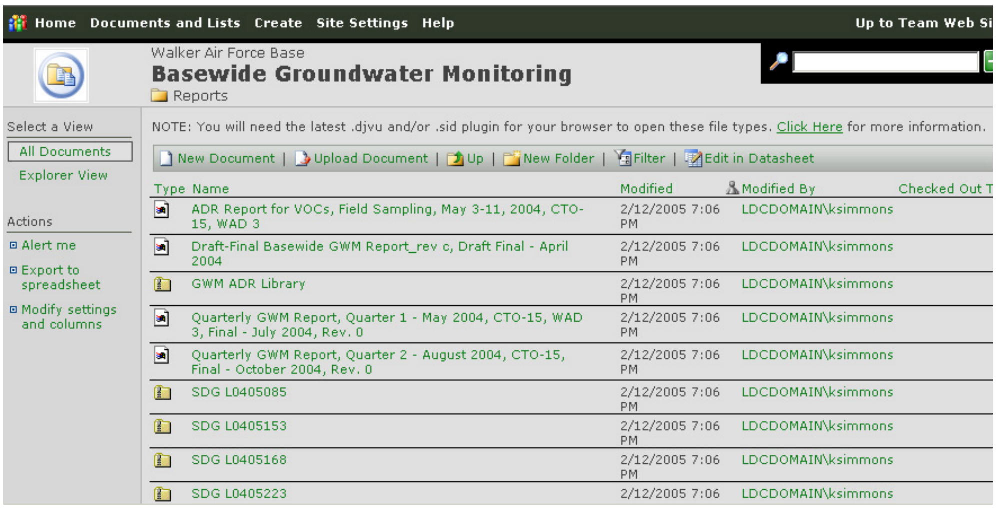
Document Collaboration

By searching the tabs on the left side of the home page, the user can get a listing of all projects documents, schedules, images, contacts, and access to the discussion board. Below in Image No. 4 is an example listing planning documents and reports.



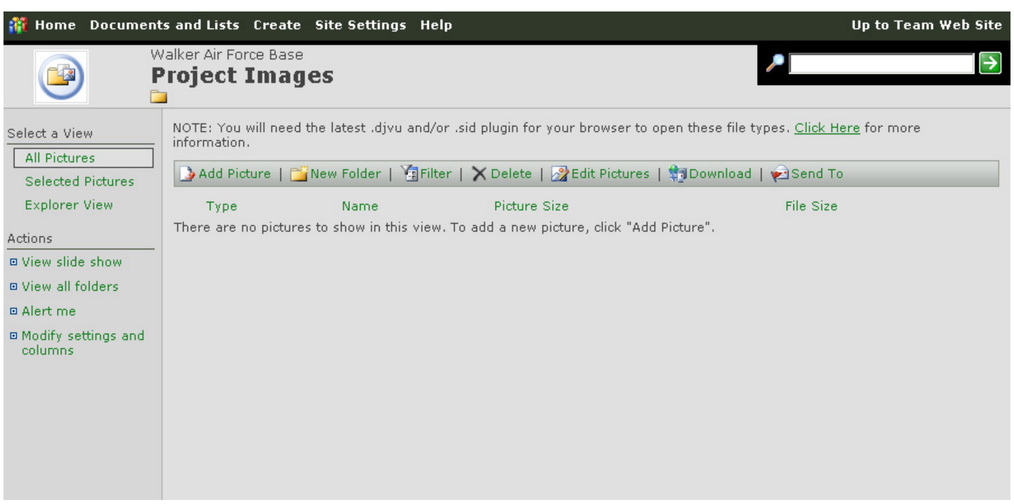
Screen Image No. 4, All documents
Basewide GW Monitoring Reports

The basewide reports can be shared via the LPMS site with the project team, regulators, and other data users. Each user will have specific privileges that will allow them to read only, download and edit, receive e-mail confirmation, etc. These settings are established by the LPMS administrator. Screen Image No. 5 below lists several project documents.

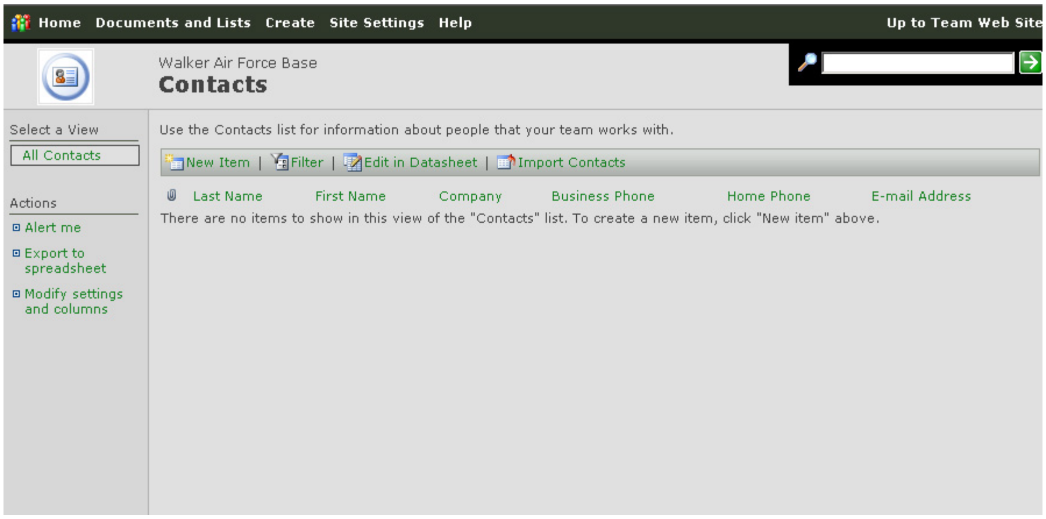


Other features of LPMS

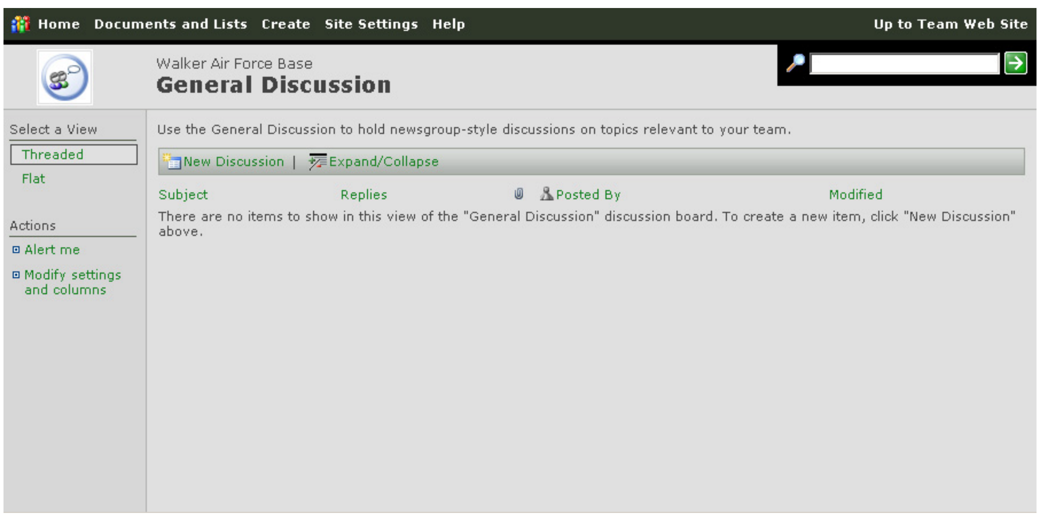
Additional features of LPMS include the use of Mr Sid images, Djvu and PDF files, listing of project contacts, a general discussion board, and an events calendar. See Screen Images No. 6, 7, 8, and 9.



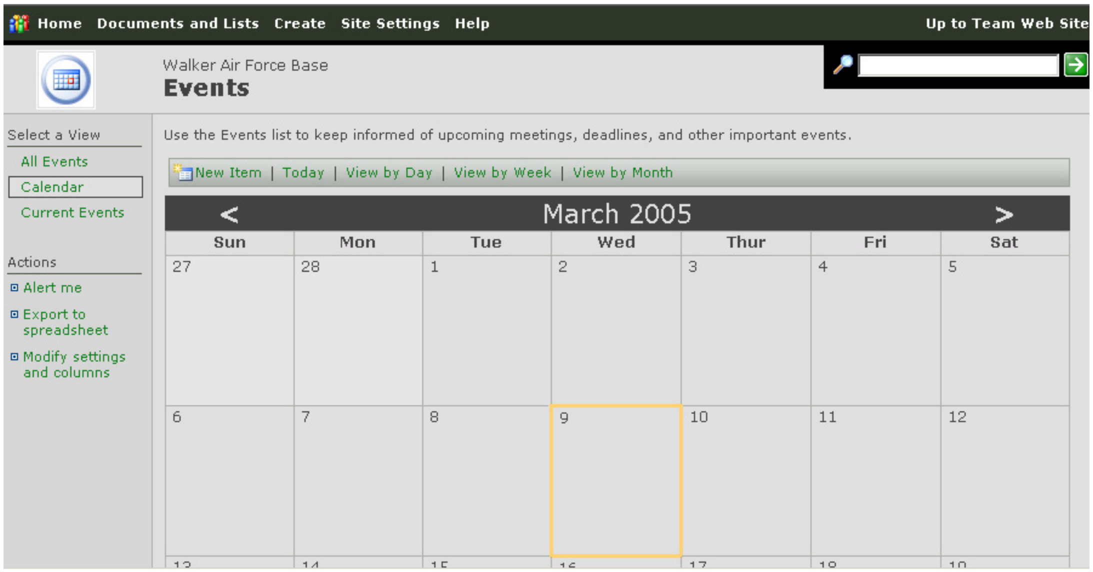
Screen Image No. 6, Project Images



Screen Image No. 7, Project Contacts



Screen Image No. 8, General Project Discussion Board



Screen Image No. 9, Project Events Calendar

In conclusion, the Former Walker AFB improved its document management and communication through the use of the web-based LPMS system. The e-mail alert and audit trail tools allowed for maintaining excellent tracking and document revision traceability.

Workshop Proposal: Implementing and Assessing Quality Systems for State, Tribal & Local Agencies

Length: 90 minutes - three main presentations with break and questions & answer

Presenters: U.S. EPA Region 5, Region 6 and Great Lakes National Program Office

Overview: Development, implementation and maturation of quality systems is rarely a straight & narrow road for most organizations. Often times, progress is viewed as moving 2 steps forward and one step backward. This workshop will discuss implementation issues and means of assessing quality systems for state, tribal and local organizations . The presenters will address practical means to alleviate roadblocks for implementing systems. The workshop will present a model for stages of implementing quality systems applicable to most organizations as well as lessons-learned based upon assessments of quality systems at various stages of maturation. The attendees should come away with not only a better understanding of common implementation issues but ideas which they may be able to utilize in their own quality systems.

Intended Audience: Federal, state, tribal and local agencies developing & implementing quality systems as well those who have QA oversight responsibilities for such organizations.

Contacts: Kevin Bolger U.S. EPA Region 5 312-886-6762 bolger.kevin@epa.gov
Don Johnson U.S. EPA Region 6 214-6658343 johnson.donald@epa.gov
Louis Blume U.S. EPA Great Lakes National Program Office
312-353-2317 blume.louis@epa.gov

Request: Prefer morning session (2nd slot >10AM) early in the conference (i.e. Wednesday) if possible

Black Lagoon Quality Plan Approval by GLNPO, MDEQ, ERRS, and USACE

Jackie Doan, Environmental Quality Management, Inc., 1800 Carillon Boulevard, Cincinnati, OH 45240

The submittal and approval of quality assurance plans can at times be a timely and tedious process. The duration may vary from 60 to 120 days, from award of a project to approval of plans. This process if a very necessary step in ensuring the documentation of planning results for environmental data operations, with the end result of obtaining the type and quality of environmental data needed for the project specific decisions and use. Most projects will have a specified, usually small number of stakeholders involved in the project planning process.

The Black Lagoon Remediation Project presents an interesting challenge for approval of quality assurance procedures. Environmental Quality Management, Inc. (EQ) performed the work under two separate contracts, one with U.S. Environmental Protection Agency (EPA) Great Lakes National Program Office (GLNPO) and one with Michigan Department of Environmental Quality (MDEQ). GLNPO used EQ's prime contract under the USEPA Emergency and Rapid Response (ERRS) program to fund and execute the work. EQ's approved Quality Management Plan for the ERRS contract was utilized to set the stage for quality management of the project. The uniqueness of EPA Region 5 ERRS QA program, normally structured under a contract QMP and QAPP, presented a different platform than standard remediation projects.

ERRS, a contract in the Office of Solid Waste and Emergency Response (OSWER) has the principal objective for the immediate removal of contaminants that may impact human health and the environment. In addition, it facilitates the prevention, reduction, and recycling of toxic chemicals and municipal solid waste, including PBTs (persistent, bioaccumulative, and toxic chemicals). EPA works to clean up previously polluted sites, restoring them to uses appropriate for surrounding communities, and respond to and prevent waste-related or industrial accidents. EPA and its federal, state, tribal and local partners reduces or controls the risk to human health and the environment at more than 374,000 contaminated Superfund, RCRA, underground storage tank (UST), Brownfield and oil sites. They also have the planning and preparedness capabilities to respond successfully to all known emergencies to reduce the risk to human health and the environment.

By definition, ERRS addresses environmental emergencies that are a sudden threat to the public health, or the well-being of the environment, arising from the release or potential release of oil, radioactive materials, or hazardous chemicals into the air, land, or water. These emergencies may occur from transportation accidents, events at chemical or other facilities using or manufacturing chemicals, or as a result of natural or man-made disaster events. While there are many other serious environmental problems with which EPA is concerned, these activities are focused generally on sudden, immediate threats.

GLNPO, under the Great Lakes Legacy Act, which was amended from the Federal Water Pollution Control Act, authorizes the EPA to carry out projects and conduct research for remediation of sediment contamination in areas of concern in the Great Lakes. EQ followed

GLNPOs Quality requirements, however they were amended to include ERRS and USACE requirements.

This type of project, multiple agencies, multiple quality systems presented a challenge and new approach. The intent of a quality management team is to implements a value-added management system for sound environmental decision through collection, documentation, assessment, and peer review. EQ's approach to quality is to work closely with operations, support and enhance the approach rather than slow or hinder project activities. The quality system documentation should be commensurate with the importance of the question that is being addressed. Step 5 of GLNPO QMP ask the following: who is the customer, what are their expectations, what type of info does the customer need, who is the supplier, and what is their responsibility. This project certainly doesn't easily lend itself to the steps noted above.

The plans submitted not only included the Work Plan, Health and Safety Plan, but also the Quality Assurance Project Plan, a Contractor Quality Control Plan, an Environmental Protection Plan, and a Soil Erosion and Control Plan. These plans were submitted to all regulatory agencies involved. To add to the complexity, the remediation schedule for plan preparation, review, finalization, and mobilization was very short, less than 30 days. EQ was successful in getting all of the plans submitted in final draft and/or final form before any work commenced. To add to the complexity, MDEQ performed the final confirmation sampling, using a subcontractor that was not brought into the process until dredging was approximately fifty percent complete. This set the stage to have the initial submitted QAPP only addressing the sampling and monitoring, prior to confirmation sampling. GLNPO utilized Computer Science Corporation (CSC) to complete the confirmation sediment-sampling portion of the QAPP.

The Plans were submitted to GLNPO, ERRS, MDEQ, and USACE for the remediation of the Black Lagoon located in the Trenton Channel of the Detroit River near Trenton, Michigan. The project involved the dredging and cleanup of contaminated sediments in the Black Lagoon that will directly result in environmental, social, and economic enhancements of the lagoon and surrounding areas. This project was performed under the authority and guidelines provided by the U.S. Great Lakes Legacy Act of 2002 and the Clean Michigan Initiative (CMI) of 1998, with joint funding by GLNPO (responsible for 65% of total project costs) and MDEQ (35% of total project costs). The dredged sediments were disposed of in the Pte. Mouillee CDF located in Lake Erie about 8 miles south of the lagoon. The Corps operates this facility, and therefore had an active participation in all work performed at the CDF.

The Detroit District of the U.S. Army Corps of Engineers (USACE) also provided engineering and project management support for the effort. The Detroit District prepared the engineering specifications and drawings for this project. The USACE regulators reviewed and approved the use of calciment for stabilization of the sediment prior to placement in the USACE confined disposal facility (CDF) at Pte Mouillee. They also reviewed and approved the hydrographic data used to calculate the dredging volumes.

The continual improvement of the quality system for this project is illustrated by the Daily Quality Control (QC) Report and in the weekly operation calls. These calls, not only provided a status of the project to all the stakeholders, but it also introduced the process for modifications, additional monitoring, and revisions to permits. The modified approach to the documentation process that this project has introduced was agreed upon during the initial implementation phase. Additional monitoring (turbidity readings along the inside and outside of the silt curtain), changes to transportation of sediments (trucking in lieu of transport via barges), as well as the procedures for the hydrographic survey were all documented in addendums to the work plan. The addendums were all discussed in detail prior to documenting in writing and submittal for signature approval.

The success of this type of approach is demonstrated by the ability of the project to adjust to changes. The initial completion date was expected to be before the more severe weather of the winter was an impact. The actual completion of dredging did not occur until April. With the changes that this extension introduced, not only the trucking of the sediments versus transport by barge, but the work was performed during the Walleye spawning season, which typically requires all dredging to be ceased. The continuance of our dredging was approved by Michigan Department of Natural Resources primarily due to the modification of the silt curtain and the additional turbidity monitoring. Both of which were documented in the Daily QC Report and revisions to the work plan.

All of these processes are components of the quality system for the project. If we recognize the importance of documenting how we can ensure effective design, including modifications, implementation, and follow up we can improve the overall quality of our projects.

Cooperation of the stakeholders during the planning phase and the complete understanding of the final objectives were critical in the process. With different regulatory agencies with oversight and approval a ‘blending’ of plan formats was necessary to encompass the different requirements and achieve the project objectives. This clearly illustrates the GLNPO concept of a graded approach to their GLLA quality management program.

The United States Environmental Protection Agency
24th Annual National Conference on Managing Environmental Quality Systems

Remediation of the Black Lagoon Trenton Channel, Detroit River, Trenton, Michigan: Post-dredging Sediment Sampling and Residuals Analysis

Judy Schofield[1] and Rex Bryan[1], Computer Sciences Corporation, 6101 Stevenson Avenue, Alexandria, VA 22304, Louis Blume and Marc Tuchman, U.S. Environmental Protection Agency, Great Lakes National Program Office (GLNPO), 77 West Jackson Boulevard, Chicago, Illinois 60604, Mike Alexander, Michigan Department of Environmental Quality (MDEQ), Constitution Hall, 525 West Allegan Street, Lansing, MI 48909.

The Black Lagoon is a 3-acre cove of relatively still water in the Trenton Channel of the Detroit River in the city of Trenton, Michigan. Mercury, PCBs, and oil and grease were detected in the sediment at concentrations exceeding the Sediment Quality Guidelines at depths from 0.5 to 12 feet below the surface of the sediment. As a result of these various environmental studies, the Black Lagoon was identified as a Priority 1 Hot Spot in the Detroit River. A jointly funded effort between GLNPO and MDEQ was undertaken to remediate the sediments in the Black Lagoon.

The lagoon is being dredged to remove the contaminated sediment up to 17 feet below the low water depth. Once dredging is completed, sediment confirmation sampling and residuals analysis will be conducted to determine the need for additional dredging or other remedial activities prior to placement of a residual cover. A 100x100-foot grid system has been established where each 100x100-foot grid comprises a remedial management unit (RMU). Residuals analysis (i.e., any remaining contamination) and the assessment for additional remedial activities will be determined separately for each RMU.

The sampling design and residuals analysis were developed in accordance with EPA's systematic planning process, specifically the DQO process. As part of the DQO process, a power curve for the sediment sampling and residuals analysis was developed in the style recommended by EPA guidance. Case study data from several sediment remediation projects were obtained and evaluated for use in planning the remedial activities, sampling design, and residuals analysis for the Black Lagoon project. Target levels were developed for three contaminants of concern (COCs) at the site.

Sediment sampling will be conducted using stratified random sampling (i.e., a combination of grid and random sampling) where sampling locations are defined such that all locations are in regular intervals over an area. The locations of samples and RMUs are oriented using global positioning system (G.P.S.) technology augmented with high-resolution aerial photography. Four composite samples will be collected within each RMU. The sampling design described above ensures coverage of the site and allows for a separate assessment of each RMU. If the data shows that the concentrations have a spatial structure as defined by a variogram, a more sophisticated RMU may be defined by kriging. After a first dredging, sediment sampling will show that:

1. Average concentrations of all COCs in each of the Black Lagoon's 100x100-foot RMUs are not significantly greater than the TLs or,
2. One or more RMUs have at least one COC significantly greater than the TL and the RMU will require consideration of additional dredging or other remedial activity.

Given the average of 4 sediment samples used to estimate the average contamination of COCs over the RMU, if the grey region is set to 5x the Target Level, then the power of the test will be 95%. The present sampling design achieves this 95% power in detecting an exceedance of the TL when the true concentration of total PCBs is 5 mg/kg within a 100x100-foot RMU. The sampling design and residuals analysis is assisting project leads in assessing and completing remediation of the site.

[1]Presenters

IMPROVING E4 QUALITY SYSTEM EFFECTIVENESS BY USING ISO 9001:2000 PROCESS CONTROLS

WORKSHOP

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United States Environmental Protection Agency

United States Environmental Protection Agency
24th Annual National Conference on Managing Environmental Quality Systems
San Diego Marriott Mission Valley
San Diego, California U.S.A.
April 13, 2005

Workshop Outline

ISO 9001:2000 Workshop Topics
Wednesday, April 13, 2005
8:30 AM - 10:00 AM

1. Introduction

- 1.1 E4 Quality System Standard
- 1.2 ISO 9001:2000 American National Standard
- 1.3 Crosswalk Between E4 and ISO 9001
- 1.4 USEPA's Quality Assurance Technical Support Program (QATS)

1. Streamlining Document Control

- 2.1 Quality Management System Document Structure
- 2.2 Documentation Requirements: E4 and ISO 9001
- 2.3 What documents should be controlled?
- 2.4 How to control documents?
- 2.5 Flowcharting to streamline documents
- 2.6 Quality Records: what are they and how to keep them?

1. Enhancing Internal Auditing Effectiveness

- 3.1 Why are Internal Audits Essential for a QMS?
- 3.2 Common Problems with Internal Auditing in Planning, Implementing, Reporting and Effectiveness Follow-up
- 3.3 Streamlining Internal Audits
  - 3.3.1 Planning
    - 3.3.1.1 Preparing the Audit Matrix
    - 3.3.1.2 Preparing the Audit Checklist
    - 3.3.1.3 Internal Auditor Selection and Training
    - 3.3.1.4 Scheduling the Audit
  - 3.3.2 Implementation
    - 3.3.2.1 Preparing for the Audit -Reviewing Relevant Records and Requirements
    - 3.3.2.2 Staying Focused
    - 3.3.2.3 Staying Objective
    - 3.3.2.4 Completing the Checklist
    - 3.3.2.4 Collecting Objective Evidence
    - 3.3.2.5 Discussing Findings with Auditees
  - 3.3.3 Reporting
    - 3.3.3.1 Using a Reporting Template
    - 3.3.3.2 Correction and Corrective Action
    - 3.3.3.3 Issuing Non-conformance Reports (NCR) or Corrective Action Reports (CARs)
  - 3.3.4 Effectiveness Follow-up
    - 3.3.4.1 Closure and Effectiveness Checks
    - 3.3.4.2 Electronic Tracking of Closure and Effectiveness Checks (Integrated Quality System)

3.3.4.3 Measuring the Effectiveness of Internal Audits and Auditors
3.3.4.4 Internal Audits Result in Preventive Actions and Continual Improvement

1. Effective Management Review and its Benefits

4.1 What is it? How is it organized? How often? Who participates?
4.2 Management Review Inputs: Internal and 3rd party audits, customer feedback, process performance and product conformity, corrective and preventive actions, recommendations for improvement, follow ups from previous Management Reviews.
4.3 Management Review Outputs.
4.4 Applying Management Review to your current Quality Management System
4.5 Benefits of Management Review.

5. Customer Focus

5.1 Customer Focus, Customer Feedback, and Quality Objectives (what are they and how do they interact?).
5.2 Demonstration of totally electronic Integrated Quality System (IQS) for combining customer contact, customer feedback, nonconformance reports and preventive actions.
5.2.1 Integrated Quality System (IQS)
5.2.1.1 Client Communication Log (CCL)
5.2.1.2 Client Satisfaction/Feedback Report (CSR)
5.2.1.3 Nonconformance Reports/Preventive Action – Continual Improvements
5.2.1.4 Customer Focus/Customer Communications/Customer Satisfaction
5.2.1.5 Corrective Action/Preventive Action/Continual Improvement
5.2.1.6 Control of Records
5.2.1.7 Internal Communications
5.2.2 Features and Functions of the IQS
5.2.2.1 Client Communication Logs (CCLs)
5.2.2.1.1 Login IDs
5.2.2.1.2 Standard software features provide quick, easy way to fill out reports
5.2.2.1.3 Tab Controls provide convenient access to components of Communication Log
5.2.2.1.4 Links to supporting files and documents
5.2.2.1.5 Connection to Client Satisfaction/Feedback Reports
5.2.3 Client Satisfaction/Feedback Reports (CSRs)
5.2.3.1 Auto-fillable reports
5.2.3.2 Categorizing and tracking client communications and feedback
5.2.3.3 Searching and organizing client communications and feedback
5.2.4 Nonconformance Reports/Preventive Action-Continual Improvements (NCR/PA-CI)
5.2.4.1 Login and Selection
5.2.4.2 Description and Resolution
5.2.4.3 Approvals and Routing
5.2.4.4 Closeout and Effectiveness checks
5.2.4.5 Searching and Reporting
5.2.5 Benefits of IQS
5.2.5.1 Minimizing Costs
5.2.5.2 Adaptability and Continual Improvement
5.2.5.3 Meeting Customer Needs

6. Supplier/Subcontractor Selection and Control

6.1 Initiating critical and non-critical supplier/subcontractor lists. What criteria to use and how to differentiate between critical and noncritical vendors?
6.2 Criteria for reevaluation and retention (or deselection) of suppliers/subcontractors.
6.3 Effective methods of controlling your supplier/subcontractor.

6. Conclusions

Speaker Biography

Clyde Hedin is a Program Manager with Shaw Environmental, Inc. who currently manages the USEPA Quality Assurance Technical Support (QATS) Contract in Las Vegas, Nevada. This contract supports the EPA OSRTI Analytical Services Branch (ASB) by providing performance evaluation samples and data assessment support to the EPA Contract Laboratory Program (CLP) and the EPA Regions. Since 2001 Mr. Hedin has led the QATS Program to achieve QMS certification to two separate ISO 9000 standards. Mr. Hedin has more than 21 years experience providing analytical chemistry and management support on various EPA Superfund contracts. He is the auditor or co-author on several papers dealing with ISO 9000 quality management systems. Mr. Hedin has a B.S. in biology from Bemidji State University, Bemidji, Minnesota. His certifications include Certified Quality Auditor (CQA) and ISO 9001:2000 Lead Auditor.

On Some Applications of Ranked Set Sampling

Bimal Sinha, University of Maryland, Baltimore County
Barry D. Nussbaum, U.S. Environmental Protection Agency

Abstract

Ranked set sampling, a concept due to McIntyre (1952), aims at estimation of the mean of a population based on measurements of some suitably selected sampling units. It turns out that RSS provides a more efficient estimate of a population mean compared to the traditional simple random sample. In this talk some basics of RSS will be presented along with two novel applications. One of the applications, which has a direct relevance to EPA, deals with estimation of Reid vapor pressure of gasoline.

COMBINING DATA FROM MANY SOURCES TO ESTABLISH EMISSION FACTORS WITH A CONFIDENCE LEVEL

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and

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Abstract

Emission factor data (e.g., g/kg) are reported by industry stakeholders, scientific papers, State Agencies, as well as EPA laboratory studies and documents such as AP-42. Usually, the data represents results of individual replicate measurements and the documents report only means and standard deviations. Emission factors are often stated in concentration units (e.g., g/kg). Since statistical distribution of concentration measurements is skewed, there may be a temptation to use the lognormal model for calculating emission factors. However, emission factors obtained as confidence bounds to be computed using averages of lognormal observations are not lognormally distributed (unlike in the case of normal distribution). In this talk, various approaches to parameter estimation of a lognormal distribution when some of the data reported are means and the others are individual observations will be discussed. Methods will be illustrated using chromium emissions data.

Quality Requirements for Audit of Data Bases

(1)
This presentation is a byproduct of an in-house consultation with the EPA Office of Technology Operations and Planning (OTOP). They had been requested (indirectly by GAO thru EPA's OIG) to estimate by sampling the error rate of one of the data base that OTOP maintained. It seemed a "fairly straight forward" simple random sampling without replacement problem, SRSWOR. As a result of this straight forward consultation we found some interesting things that we would like to share with you today.

(2)
Comment on Abstract
At EPA there are database which need to be examined for correctness. On measure of correctness Is the error rate. That is:
[Total Number of Errors in the data base)/(Total number of elements in the data base]

(Or more simply as # Defective Reports / Tot # Reports = d / N)

Next realize that the underlying distribution is the hypergeometric, which is discrete and asymmetrical. Later on we see that this causes problems in applications [but not in theory]

(3)
In this talk we will proceed as follows:

1. Give an expanded statement of the problem –
Estimating Error Rates in EPA Databases for Auditing Purposes
2. Illustration of one of the problems
3. Tell why we are bothering to work on this very old problem?
4. Give the procedures/methods we use use? What sample size(s) did we obtain?

We applied the following procedure/programs:

Cochran's approximation [an old fashion approximate solution]
Rat-Stats [Department of Health and Human Services]
EZ-Quant [Army Audit Agency] approx
IDEA [Caseware International Inc.] *
EZ-Quant s approx
UCLA Software [htpp://calculators.stat.ucla.edu/]

* EPA has purchased around 66 of these programs at about $ 650 each

5 What did we find? What sample size(s) did we obtain?
Surprisingly, the various sample sizes generated by the various methods were all different!! But all these different answers are all correct if you read the fine print. In general the methods [with the possible exception of the Cochran method] give conservative results in the sense that we get the stated confidence or **better**

(4)
Let's talk about the problem
We have a Finite Population of say reports (N items that in this case happen to be reports).

To estimate the error rate, phat, with an associated confidence Interval (CI) we need a preliminary estimate of Error Rate. This has been given to us as 15%, by the "customer" (i.e. the folks down the hall).

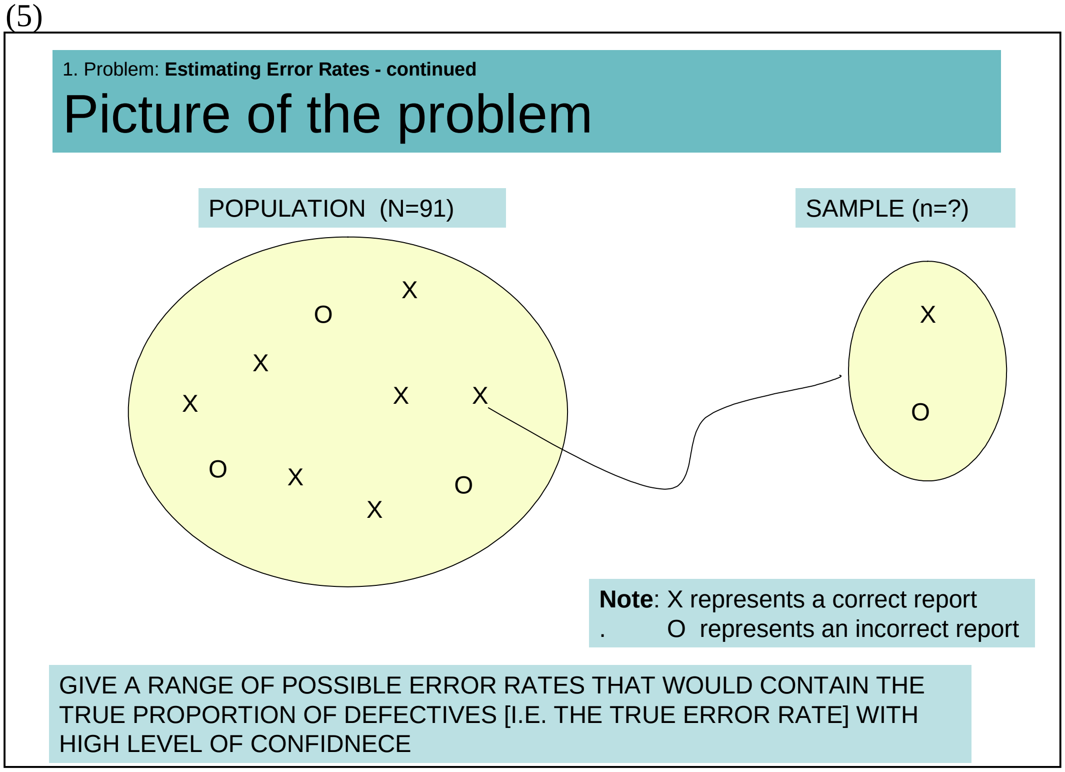
We estimate the real Error Rate, p,

by phat = Defectives from a Random Sample

And: Find an interval around phat. i.e. a range of possible values

THAT WOULD CONTAIN THE TRUE PROPORTION OF DEFECTIVES WITH "HIGH LEVEL OF CONFIDNECE"

(5)



(5)
To beat this problem to death here is a visualization of the sampling problem
The big oval represents the total population to be sampled. The X's represent items in the sample that are correct, while the O's represent items that are incorrect. Once an element is sampled, it can be examined and classified see if it is correct or incorrect. We could of course sample all 91 items in the data base and get an exact error rate for the population (i.e. for the data base.) But

sampling all items may be too costly. Frequently we can get a “good” estimate of the proportion of defectives (sometimes called the error rate) by taking a sample of, say 50 or 60, from the 91 items. This may gives us a reasonably good estimate of at the proportion of defectives without having to check all the items. Before we go any further, I want to give a little background on this work

(6)

2. Illustration of the problem

And why do we bother with a more than 500 year old problem

Slide 6 give a specific sampling problem
The null hypothesis [aka Ho] is a statement that states that there are no differences between observed and expected data.

When we apply to legitimate procedures we get two sample sizes, 47 and 63

(7)

Consider these results. What we get is surprising.

We more accurately meet the specification of the problem with 47 samples than with 63 samples. What is more surprising is that method 1 is an approximation procedure

WHAT IS GOING ON

This was an unexpected result… especially when you realize the sample size of n =63 came from a respected source

Is this just a fluke or is something else happening maybe I don’t quit understand. This is another case of having a big jump from theory to applications. In theory, you simply apply the hypergeometric to get your estimate and a .95 CI. And that’s the end of the story However, applying the hypergeometric was a mess and in the past and even now it’s tricky, all sorts of approximations are used to avoid actually using it.

From a theoretical view point this is all very straightforward. The hypergeometric distribution has been known at least as far back as the 16’th century, although the name “hypergeometric” is of the 1930’s vintage. Yet, if you look at the literature, the hypergeometric and/or its application to srswor still a fairly active topic in applied work. [See Google for 18K references.] The reason for this is that this is a discrete-asymmetric distribution with probability formulas that are hard to deal with. So even in present times people use various approximation and or computer programs to deal with them. As they say, the devil is in the details

(8)

2.A. It's a big jump from theory to applications.
Let's take a closer look at the problem (slide8) Basically you don't have symmetric CI's. So you results are less intuitive, and this can be led astray. The symmetric CI is from a standard normal distribution with mean=u and sd. = sig.
This type of CI is what you usually see in Stat 101. The highly asymmetric CI results from the corresponding hypergeometric distribution with mean=u and sd = sig.
So, approx by the normal [of much symmetric distribution] can be misleading

Another Annoyance: We are dealing with a discrete distribution.
So, you can never have p = 15%.
The closest we can get is 14/91 = .1538… Or 13/91 = .14285..
In the applications for this talk we assume 14/91 = .1538…

(9) Slide9
This is a classical approximation that comes from the "well known" Cochran book.

(10)Slide 10
For those of you who have succeeded in forgetting the hypergeometric distribution , here it is?

With the usual definitions:
P(X=k) is the probability of drawing k defective from our data base of 91
N = # of items in the Data Base [91]
D = # of assumed defectives [14}
n = the sample size.. This is what we are after

(11) Slide
3C. EPA routinely audits certain data bases. The solution to this problem goes back at least to the 16'th century Ref: Google

The sample size should satisfy the following conditions:
1. The Universe of items is N = 91 In this case there are 91
2. We assume the error rate is 15% [which is not really possible here]
3. We want at least a .95 confidence interval (CI) for our estimate
4. We want a Lower Error Limit of 5% and an Upper Error Limit of 25%
[i.e. The length of the .95 CI should be of size 15% + or - 10% or smaller or put another way, the length of the CI should be no greater than 25% - 5% = 20%]

A similar question is asked for a Universe of items of size N = 68.

(12)
3C (continued)
So now we begin to see some of the problems;
Non-symmetry in CI's limits the accuracy of some approximations

Discreteness of the hypergeometric really limits you choice in specifying

In addition to Cochran's approximation we have other more modern tools available.
Since the Cochran procedure is an approximation we should check it with other tools. We do this and then use yet another piece of software, (SPlus), to evaluate the realized confidence level from the various programs we used.
When we checked the Cochran approximation with other audit software tools made for this type of sampling we got surprised.

(13)Slide
4. What methods/procedures did we use?

1. Cochran's approximation [Sampling Techniques by Cochran, 1953]
2. Solution via Rat-Stats [Dept of Health and Human Services ver. 1.0]
3. Solution via EZ-Quant [Defense Contracts Audit Agency ver 1.0.1]
4. Solution via IDEA [Commercial software from Caseware International Inc.]
5. Solution via the UCLA Stat page [http://calculators.stat.ucla.edu/]

(14)Slide
What did we find?

Comparisons of Sample Size to Achieve a .95 CI Using Various Procedures

Method Used	Sample Size Calculated for .95 CI	Calculation of "Exact " CI Using S-Plus	"d" in terms of defects*
Cochran	47	.9592	7
IDEA [2004 Ver]	60	.9504	8
Rat-Stats	63	.964	7
EZ Quant	67	.954	6
UCLA Stat page	63	.964	7

* smaller is better

Comparisons of Sample Size to Achieve a .95 CI Using Various Procedures

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IDEA [2004 Ver]	60	.9504	8
Rat-Stats	63	.964	7
EZ Quant	67	.954	6
UCLA Stat page	63	.964	7

* smaller is better

This is all very unexpected – to me-
All these programs are legitimate. What gives?
I think that they all have different rounding procedures…but I’m not sure.
But they are all “conservatively correct”

(15)

4. What did we learn?

6. What did we learn

1. Devil is in the details.
2. So, when does all this make any difference: 47 vs 67 Who cares?
3. Lazy people and bean counters

: 4. Sample sizes of 47 , 63, 67 1000 So what?

5. Aren’t all these answers OK if you read the fine print. Bu

6. Applications , even simple one can cause you problems if you’re not careful

7. If the answer to your sampling problem is important and you are using a complex software package that was not produced in-house, you’d best get some expert help from someone that’s familiar with the underlying theory involved

Spatial Population Partitioning Using Voronoi Diagrams for Environmental Sampling Data Analysis

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Abstract

Approximate normality, or at least symmetry of the data distribution is an implicit assumption of kriging, computation of an Upper Confidence Limit (UCL), and the number of samples required for future sampling at a contaminated site. The geostatistical method of kriging provides the best linear unbiased estimates of contaminant concentrations and also the standard deviations of these estimates. Kriging is a useful tool when concentration data are spatially correleted and a model for the spatial dependence (variogram) can be estimated from the site data. In situations, when the variogram model is very noisy, the use of kriging is not recommended. Moreover, the formulas for computing a UCL and for calculating the number of samples also break down when the data distribution is heavily skewed. The method of spatial population partitioning is developed as an alternative to kriging to handle cases when collected samples do not provide sufficient spatial coverage and/or a reasonable model for spatial dependence cannot be estimated from the data. The method of spatial population partitioning as proposed in this article combines the statistical method of univariate population partitioning and the Voronoi diagram from computational geometry and spatially partitions the site into several statistically homogeneous sub-areas. The proposed method also allows one to compute UCLs for each sub-area, and the number of samples required for future sampling in each sub-area. When used in conjunction with a Conceptual Site Model (CSM) of the site under investigation, the proposed method of spatial population partitioning can lead to substantial cost-saving.

1. Introduction

The occurrence of mixture samples from two or more normal (or lognormal) populations has been well recognized in several applied areas of interest such as biology, geology, medicine, reliability, and the environmental sciences (see Singh, Singh, Engelhardt, [1], [2]). Samples from hazardous waste site investigations frequently arise from two or more statistical populations. For example, a data set of contaminant concentrations from a Superfund site can be thought of as a mixed sample of background concentrations plus the concentration values from one or more plumes. However, one of the assumptions required to compute the relevant summary statistics (e.g., sample mean and standard deviation (sd), a 95% upper confidence limit (UCL) of the mean, etc.) is that one is dealing only with a single statistical population (e.g., one homogeneous part of the site, site specific background, etc.). Violation of this assumption can lead to the incorrect usage of statistical models and techniques: for example a normally distributed data set with a few outliers can be incorrectly modeled by the lognormal distribution with the lognormal assumption hiding the outliers. Also, the mixture of two or more datasets with significantly different mean concentrations, such as the one coming from the clean part and the other taken from a contaminated part of the site, can be incorrectly modeled by a lognormal distribution, which probably is one of the reasons for the frequent use of the lognormal distribution in environmental applications. The use of Land's H-statistic, recommended by EPA guidance documents ([3]), can lead to an unreasonably high UCL of the mean contaminant concentration (see Singh, Singh, Engelhardt, [1]), as shown by the following simulated example.

Example 1. A simulated mixture dataset of size fifteen (15) has been generated from two normal populations with the first ten observations from the cleaner area of a site represented by a normal population, $N(100,50^2)$, with mean, 100, and standard deviation, 50, and the last five observations coming from a contaminated part of the site represented by a normal population, $N(1000,100^2)$. The simulated data are: 180.5071, 2.3345, 48.6651, 187.0732, 120.2125, 87.9587, 136.7528, 24.4667, 82.2324, 128.3839, 850.9105, 1041.7277, 901.9182, 1027.1841, and 1229.9384.

Figure 1: Test of normality for data of Example 1

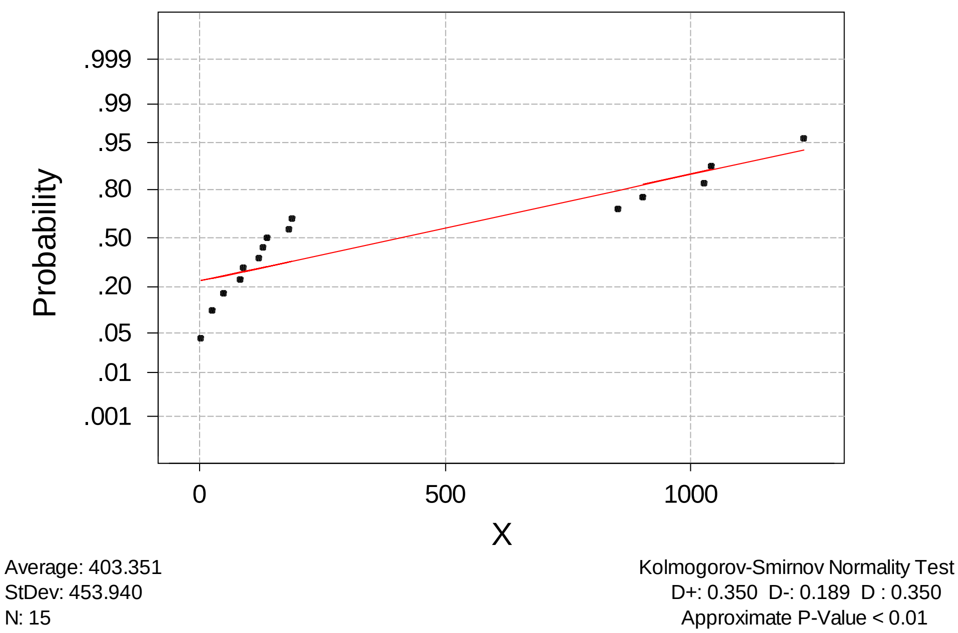
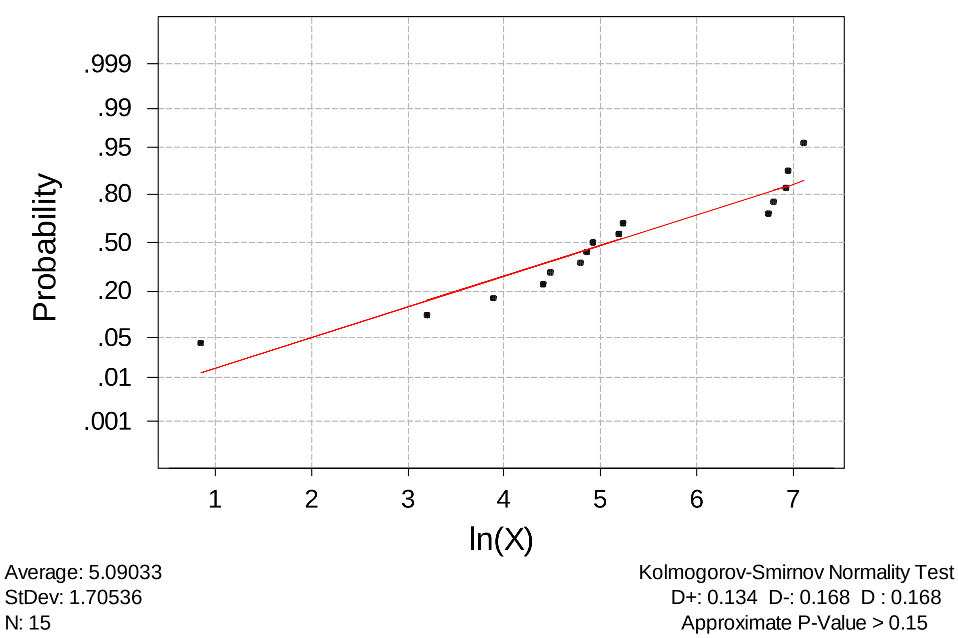


Figure 2: Test of lognormality for data of Example 1



The data of Example 1 failed the normality test based on several goodness-of-fit tests, such as the Shapiro-Wilk's W test, and the Kolmogorov-Smirnov (K-S) test (Figure 1). However, when these tests were carried out on the log-transformed data, the test-statistics became insignificant at the "=0.05 level of significance (Figure 2), suggesting that a lognormal distribution provides a reasonable fit to the data. Based upon the K-S test (Figure 2), one might incorrectly conclude that the data come from a single lognormal population. There is no substitute for the graphical display of data. The normal probability plot for the log-transformed data as given in Figure 2, suggests that there are at least two different populations present. The true mean of the mixture population is μ_1 = 400. The values of the sample mean, sample sd, and coefficient of variation computed for the raw data (x) and log-transformed data (y) are, respectively given as follows:

$$\bar{x} = 403.35, s_x = 453.94, CV = 1.125$$
$$\bar{y} = 5.090, s_y = 1.705, CV = 0.34$$

If it is assumed (incorrectly) that the population is lognormal, then the minimum variance unbiased estimates (MVUE) of the mean, μ_1, sd, σ_1, and standard error of the mean are: 572.98, 1334.56 and 290.14, respectively (Singh, Singh, Engelhardt, [1]). The 95% UCL of the mean, μ_1, computed using the H-Statistic is 4296.8. This H-UCL is orders of magnitude larger than the true mean, 400, of the mixture of two normal populations. Obviously, the cleanup decision or the background level estimation based upon the inflated H-UCL value of 4297 would be inappropriate.

The method of population partitioning has been developed to compute UCLs (e.g., as estimates of exposure point concentration terms in exposure and risk assessment studies) of the mean contaminant concentration for different parts of the site, and also to determine the number of samples for future sampling. In order to determine the number of samples for future sampling based on past samples from the site, the assumption that the data distribution is normal is required. The method of population partitioning splits the site data into several approximately normal sub-populations, and the numbers of samples are calculated for each sub-population separately. This typically results in a smaller total number of samples than that obtained by using the sample variance of the entire data set from the site in the number of samples formula (EPA, [4]). The method of population partitioning as proposed in this article, therefore, can lead to a significant reduction in cost of future sampling at the site.

The method of population partitioning was originally developed as an alternative to kriging (Singh, Singh, Flatman, [5]). Kriging is the most commonly used geostatistical method for site characterization of a contaminated site (Weber and Englund, 1992, 1994). Contaminant concentration data from the site are first used to estimate the variogram model, which in turn is used to compute the best linear unbiased estimates (BLUEs) of the contaminant concentrations at unsampled locations of the site. There are situations when the data does not seem to be spatially correlated. There are also examples of sites for which the presence of a few hot spots gives the appearance of good spatial correlations in the data. The method of population partitioning was developed to handle such cases. The method can also be applied in the determination of the number of samples needed to characterize those parts of the site, which have not been sampled.

In order to compute meaningful statistics, one must go through an extra step of population partitioning - all relevant statistics should be computed separately for each of the sub-populations. A problem faced by the project manager at a contaminated site is to spatially divide the site into two or more statistically homogeneous parts. The proposed population partitioning method can be used to split a skewed data set into two or more normally distributed sub-samples (called sub-populations in this paper). The details for univariate population partitioning are given in Singh, Singh and Flatman [5], and for multivariate population partitioning the details are given in Singh and Singh [6]. Section 2 briefly describes the method of univariate population partitioning. The Voronoi diagram structure from computational geometry can also be applied for spatial partitioning of sample points distributed in the plane into component clusters, as described in Section 3. In Section 4, we discuss a few simulated and real examples for illustration purposes.

2. Univariate Population Partitioning

For univariate population partitioning, a simple stepwise method based upon normal Quantile-Quantile (Q-Q) plots can be used [5]. The stepwise population partitioning procedure requires construction of a Q-Q plot at each step. Populations with higher concentration levels are identified first. Each step identifies a sample from a different population. Classical or robust procedures can be used to partition a given mixture sample into its component populations. Data-appraised classical or robust confidence limits for the individual observations placed on the same Q-Q plot produce a more precise estimate of the cut-off point between two adjacent populations. This reduces the subjectivity involved in choosing the inflection point from the graph. Details of this procedure are given in Singh, Singh, and Flatman [5]. A slightly modified version of the above procedure consists of using the normal probability plot and the Kolmogorov-Smirnov (K-S) test of normality. The modified version was used for the population partitioning of surface soil concentrations of arsenic, manganese, DDE, antimony, and thallium at a Superfund Site. Some of those results are discussed in Section 4. The modified version is briefly described as follows.

1. Sort the contaminant concentrations data in ascending order.

2. Perform the K-S test of normality on the entire data set; if the K-S test results in accepting normality, then STOP.

3. If the K-S test rejects normality in Step 2, then look for break points and/or inflection points in the normal probability plot so that the plot gets partitioned into two or more line segments. This method involves trial and error, and can take several iterations. High outlying observations (if any) are identified first; sub-populations with higher concentrations are identified next, and so on.

4. Partition the sample according to the break-points suggested by the normal probability plot(s) of Step 3.

5. Run the K-S test of normality for each of the sub-populations.

6. If all sub-populations approximately pass normality then stop; otherwise, try to redefine the sub-populations (by moving the break points around), each time running the K-S test for normality. Label each sample by its sub-population number; we have used 1 to

indicate the sample with lowest concentrations, 2 to indicate the sample with second lowest concentrations, and so on.

7. Generate a post plot, that is plot the sub-population numbers spatially (i.e., generate a bivariate plot of (Easting, Northing), and label each observation by its sub-population number).

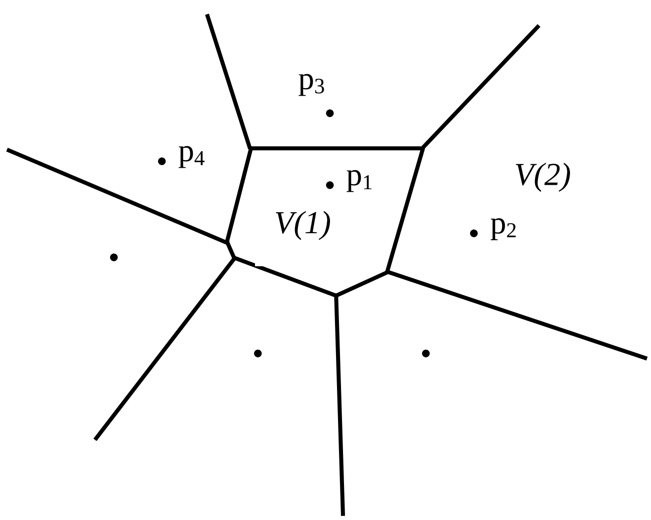
NOTE: The presence of a large number of non-detects can have a significant impact on the result of the normality test. There may be samples on both ends of the concentration range that do not pass the normality test. Declare these samples as Extremes. Extremes at the upper range are outliers and may need special attention (e.g., remediation).

3. Voronoi Diagram and Spatial Population Partitioning

A structure, useful in capturing the proximity relationship among points distributed in two-dimensional space, is Voronoi diagram. The properties of Voronoi diagrams have been studied by many researchers in the computational geometry community [7-8]. Computational geometers have proposed several data structures to represent the Voronoi diagram of point sites [7-8]. These data structures have been used to develop fast algorithms for computing Voronoi diagrams and other related structures, such as: Delaunay triangulation, relative neighborhood graphs, and Gabriel graphs [9]. The formal definitions of these structures can be found in references [7-9].

The Voronoi diagram of a set of point sites, $p_1, p_2, p_3, \ldots, p_n$, in the plane is the partitioning of the two dimensional plane into n convex cells, $V(1), V(2), V(3), \ldots, V(n)$, such that all points in $V(i)$ are closer to point site p_i than other point sites as shown in Figure 3.

Figure 3: Voronoi Diagram of Seven Point Sites



The Voronoi diagram structure can be applied for partitioning population points distributed in the plane into component clusters. Consider n points, $q_1, q_2, q_3, \ldots, q_n$, distributed in the

Euclidean plane. The population points consist of m component types, $C_1, C_2, C_3, \ldots, C_m$, where m is less or equal to n. The population partitioning problem is to partition the plane into m regions, $r_1, r_2, r_3, \ldots, r_m$, such that all points in component C_i lie in the region r_i and that all points in r_i are closer to one of the points in C_i than to other points. It may be noted that a region r_i may not be connected.

In order to perform population partitioning by using the Voronoi diagram, we can first compute the Voronoi diagram of points $q_1, q_2, q_3, \ldots, q_n$, representing the population distribution and obtain the corresponding Voronoi cells $V(1), V(2), V(3), \ldots, V(n)$. If two Voronoi cells corresponding to the same component share a boundary edge then we combine those cells. When all Voronoi cells corresponding to the same components are combined we get the population partitioning.

We implemented the spatial population partitioning algorithm using the Voronoi diagram in the Java programming language. We imported the Delaunay triangulation Java class developed and maintained by Joseph O'Rourke and his group [8] at the site [http://cs.smith.edu/~orourke]. Our program accepts the output generated by the Delaunay triangulation program available from this site and process it to have the representation in a Doubly Connected Edge List (DCEL) data structure [7-8]. In DCEL representation, it is convenient to traverse the edges and faces of Delaunay triangulation. From the DCEL representation of Delaunay triangulation, our program computes the Voronoi diagram by considering the graph theoretic dual of the Delaunay triangulation. Using this representation of the Voronoi diagram, regions corresponding to population components are extracted by combining Voronoi cells of the same components that share common boundary edge. The input points representing a population distribution can be entered by a mouse click on the display canvas of the graphical program interface. If necessary, input data can be read from a file or pasted to the data pane. The data points can be adjusted by selecting them by a mouse click and by performing a drag operation as necessary. The generated output consisting of regions corresponding to the population components is displayed graphically on the canvas interface. Each population component region is gray-scaled or colored differently for easier visualization.

The algorithm was applied on some simulated and test data sets taken from environmental applications. It is observed that Voronoi diagrams provide better spatial visualization of partitioned results than a simple post plot. Thus, once univariate population portioning has been carried out, Voronoi diagrams can be used to spatially visualize the various sub-populations. The program was executed on some simulated and real data sets. Some snap-shots of the population partitioning output generated by the algorithm are as shown in Examples 2 and 3 discussed in the next section.

4. Examples

Example 2. In this example, we consider a simulated site (Figure 4) with varying degrees of contamination: the clean part (A) of the site has contaminant concentration distributed as N(0, 1); a part (B) that is moderately contaminated as a N(5, 1); another part (C) of the site is highly contaminated as N(20,4) population; in addition, a hot spot exits (D) at the site that has contaminant concentration distributed as a N(100,10) population. A total of 142 samples are collected from this site, with 100 samples falling in the clean part (A) of the site, 30 in the moderately contaminated part (B), 10 in the highly contaminated part (C), and 2 from the hot spot (D). The sample locations in this simulated example are given on a grid. A few parts of the site have a concrete pad (shaded areas in Figure 4) and therefore no samples are taken from these parts. The full data set is given in Table A1, Appendix A.

Figure 5 shows that the data set of 142 observations fails the normality test. The method of modified univariate population partitioning, as described in Section 2, applied to this data set produced three sub-populations and two extreme observations. Figures 6 - 8 show that the data in each of the three sub-populations produced by the method of population partitioning pass the normality test.

Figure 9 shows the results of spatial population partitioning obtained using Voronoi diagram algorithm. The labels on the sample locations are their sub-population numbers. Since the separation in the four normal sub-populations used in this simulated example was quite large, the results obtained from the population partitioning method had no classification errors. For this simulated data set, both of the population partitioning methods: univariate population partitioning and Voronoi spatial partitioning procedures yield accurate partitioning results. Next we consider a few real data sets.

Figure 4: Sampling locations for simulated site of Example 2

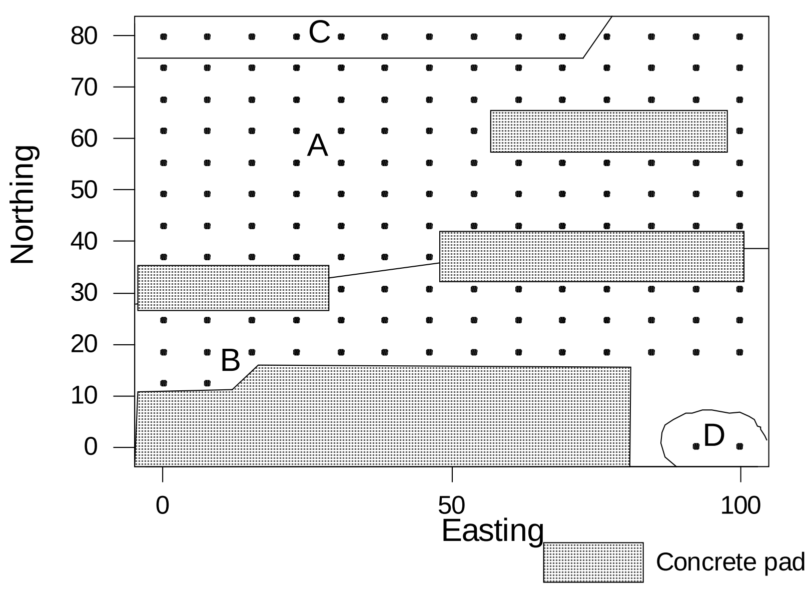
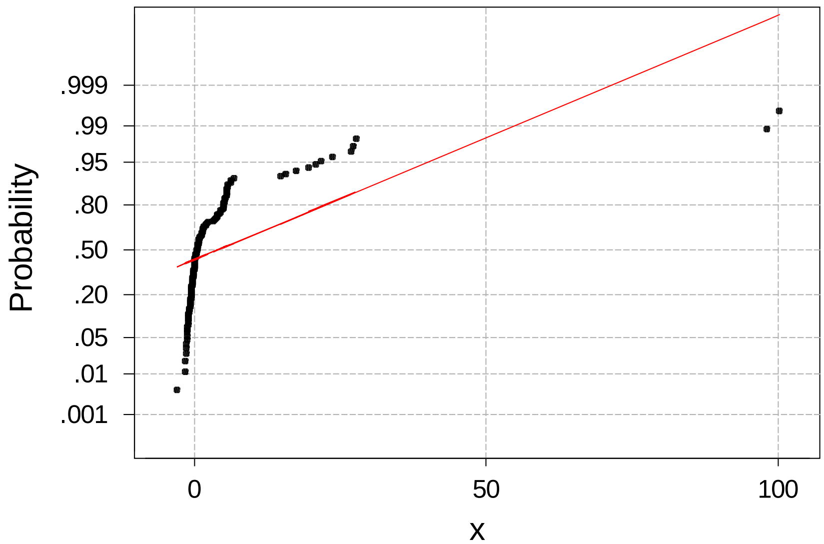


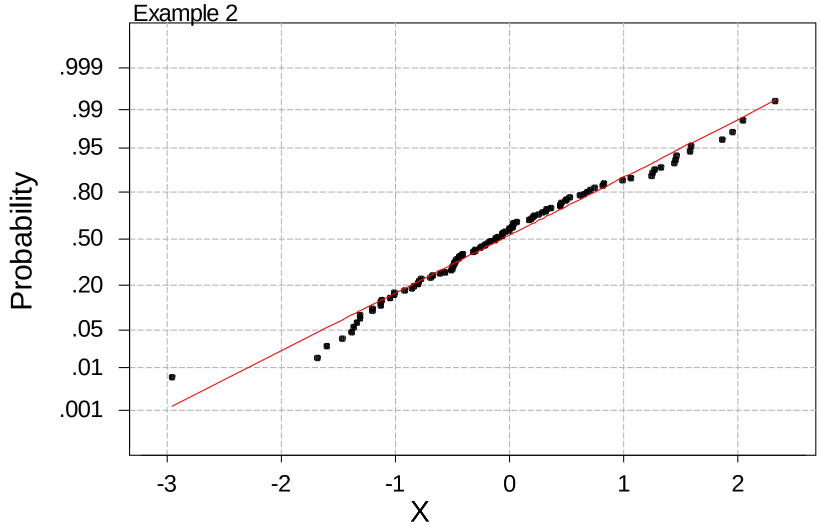
Figure 5: Test of normality for data of Example 2



Average: 3.89773
StDev: 12.8242
N: 142

Kolmogorov-Smirnov Normality Test
D+: 0.337 D-: 0.325 D : 0.337
Approximate P-Value < 0.01

Figure 6: Test of normality for Subpopulation 1 of Example 2



Average: -0.0673852
StDev: 0.937505
N: 100

Kolmogorov-Smirnov Normality Test
D+: 0.076 D-: 0.050 D : 0.076
Approximate P-Value > 0.15

Figure 7: Test of Normality for Subpopulation 2 of Example 2

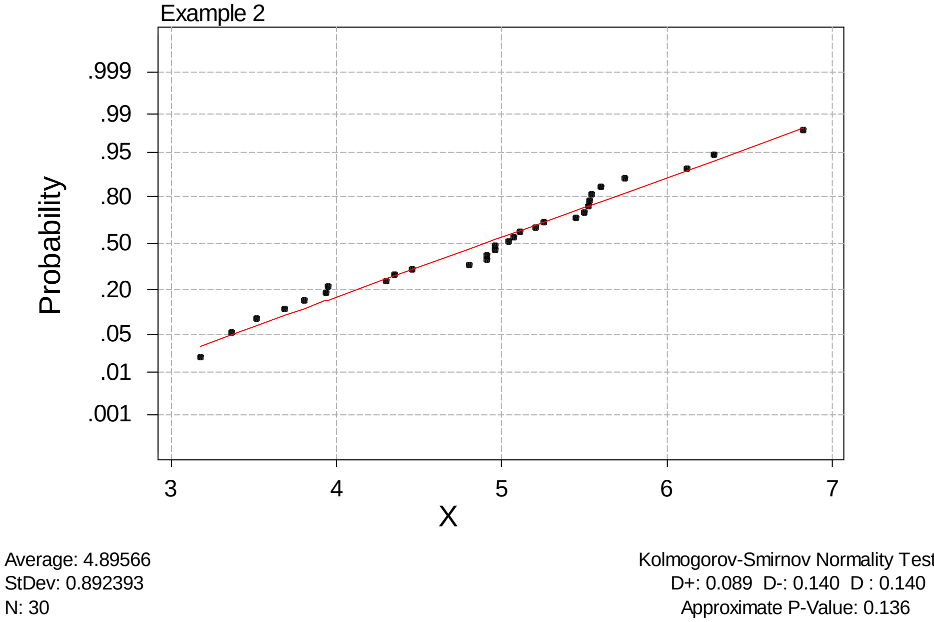


Figure 8: Test of Normality Test for Subpopulation 3 of Example 2

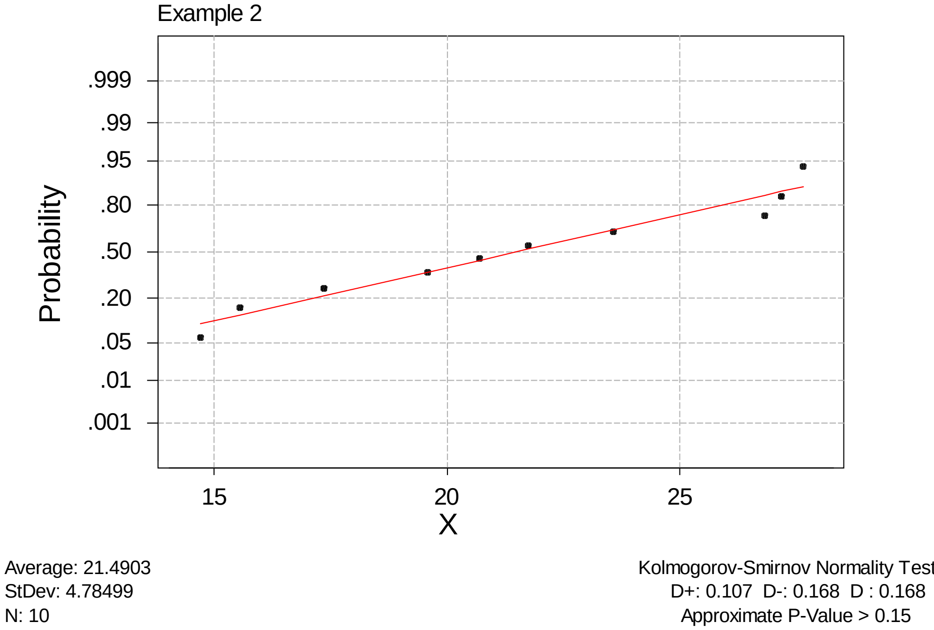
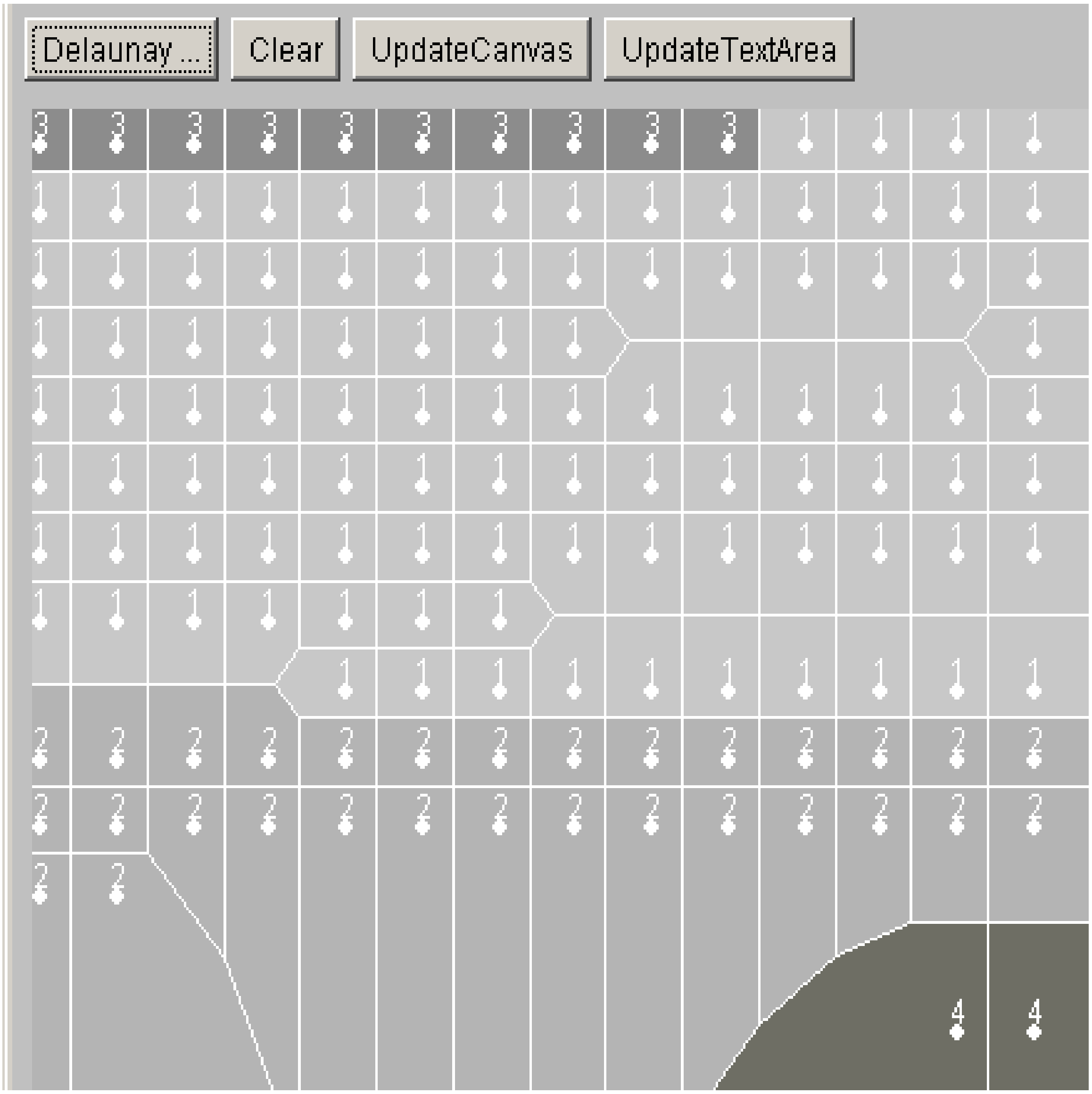


Figure 9: Spatial population partitioning results for Example 2



Example 3. The data set for this example has been taken from former wastewater effluent evaporation ponds and ditches at an industrial site (called the Site in this example). The contaminants of potential concern (COPC) at the Site included metals (e.g., aluminum, arsenic, cadmium, lead, manganese, magnesium), perchlorate, pesticides (α-BHC, β-BHC, DDD, DDE, DDT), and several semi volatile compounds (SVOCs) and volatile compounds (VOCs). In this paper, we present the spatial population partitioning results for DDE and lead only.

Figure 10: Population partitioning results for the observed DDE concentrations at the Site used

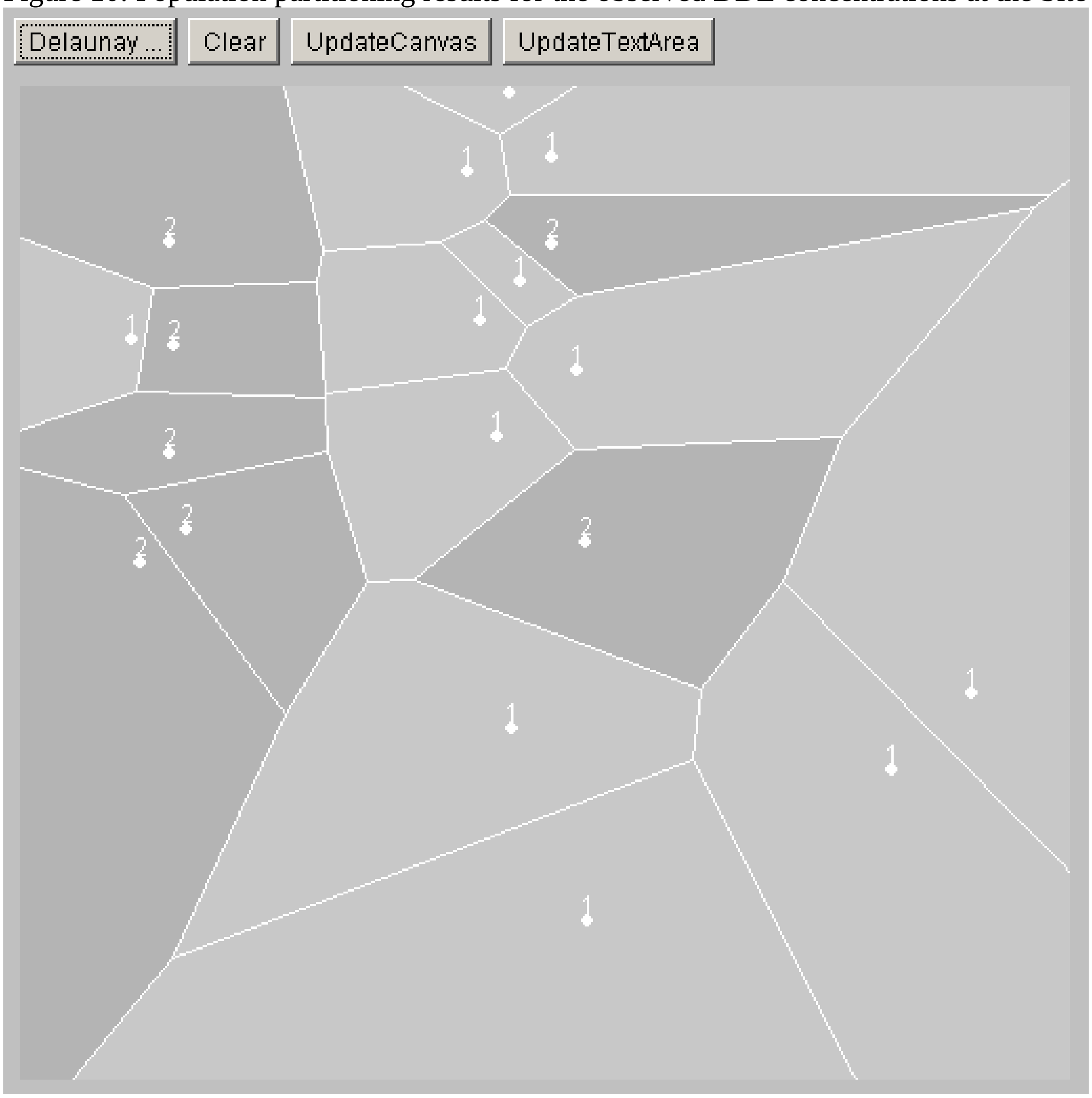


Table 1. Descriptive Statistics for DDE by Sub-Population

Sub-Population	N	Mean	StDev	L95%	U95%
1	12	0.00733	0.0053	0.003963	0.010697
2	7	0.2274	0.164	0.075725	0.379075

Figure 11: Population partitioning results for the observed lead concentrations at the Site

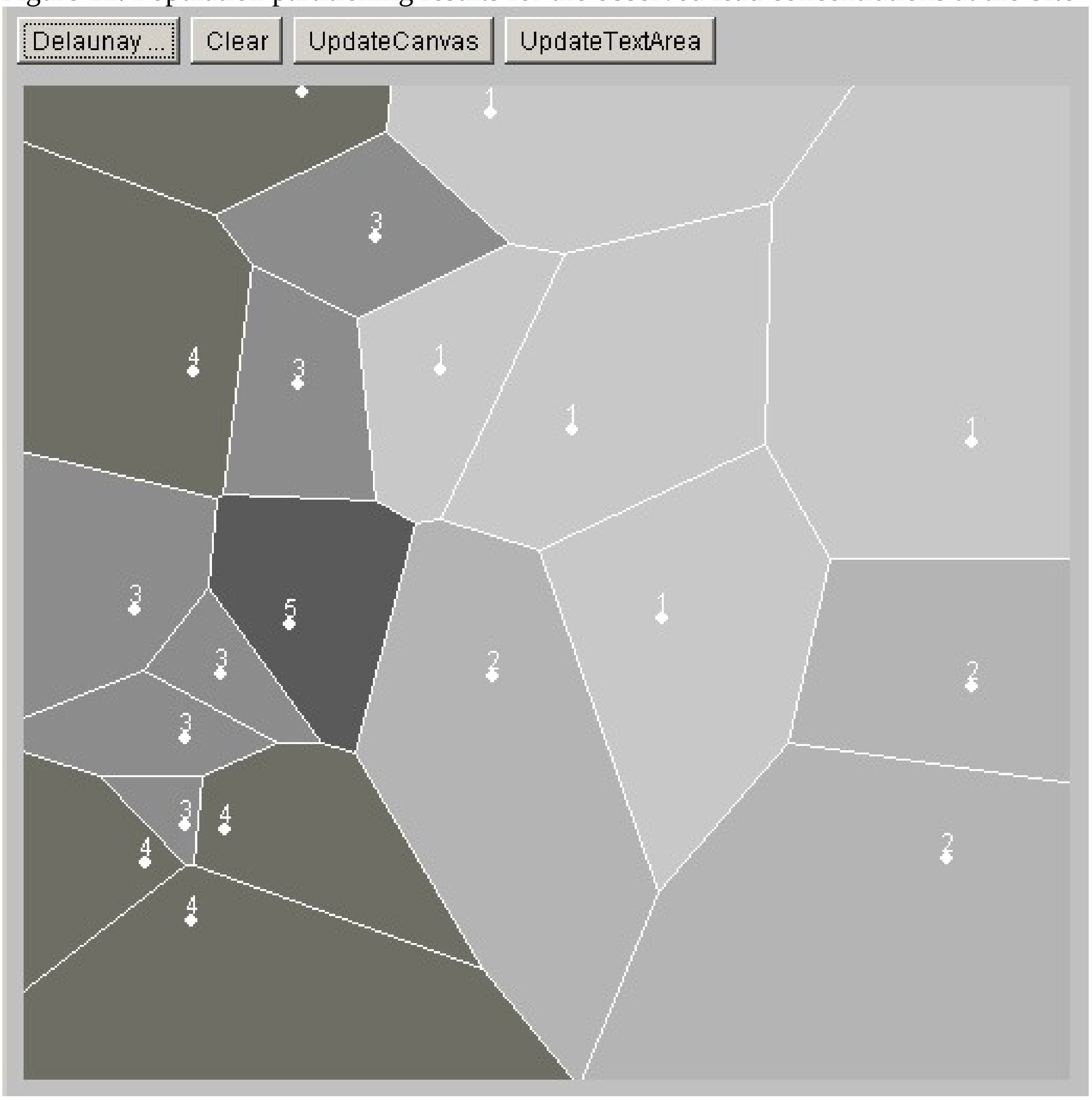


Table 2. Descriptive Statistics for lead by Sub-Population

Sub-population	N	Mean	StDev	L95%	U95%
1	6	3.817	0.866	2.90819	4.72581
2	5	14.6	2.97	10.91225	18.28775
3	13	48.77	14.83	39.80832	57.73168
4	5	108.8	18.36	86.003	131.597
5	1	290	*		

Figure 10 has the Voronoi population partitioning results for DDE. Table 1 has the descriptive statistics for DDE for the two sub-populations obtained using univariate population partition (on a sample of size 19) as described in Section 2. Spatial Voronoi algorithm was then used on the partitioned DDE data set which resulted in a partition as shown in figure 10. The samples (Voronoi Cells) are then labeled using population numbers (1 and 2 here) as obtained using univariate population partitioning. It should be noted that the means of the two sub-populations thus obtained are quite different suggesting a good separation between the two sub-populations. This is spatially enhanced by spatial Voronoi partition as shown in Figure 10. A 95% UCL of the mean representing the exposure point concentration can be computed separately for each of the two sub-populations.

Figure 11 has the spatial population partitioning results for lead based upon a sample of size 30. The univariate population partitioning algorithm yielded 4 sub-populations and one outlier (labeled by sub-population 5). Each of the 4 sub-populations passes the K-S normality test. Voronoi diagram with respective sub-population labels is given in Figure 11. The descriptive statistics for the five sub-populations are summarized in Table 2. The means of the sub-populations are significantly different from one another suggesting a good partition of the Site under investigation. Population partitioning results are spatially enhanced using Voronoi diagram as shown in Figure 11. Sub-population 5 consists of a single outlying value of 290 ppm. This area may represent “hot-spot’ needing special attention. Meaningful defensible exposure point concentrations can be computed separately for each of the 4 sub-populations.

Let us suppose that the action level for lead for this Site is 100 ppm. In other words, if the mean lead concentration is above 100 ppm, then some remediation may be needed at this Site. If the project manager of the site wants to collect additional samples to make remediation decisions at the site, then the number of future samples needed can be calculated using the following formula (EPA, [10]).

$$n = \frac{(z_{1-\alpha} + z_{1-\beta})^2 s^2}{\Delta^2}$$

where:

$z_{1-\alpha}, z_{1-\beta}$ = the false rejection and false acceptance normal deviates

s^2 = sample variance calculated from the existing available data

$\Delta = C_s - \mu_1$ = margin of error: for this example, let Δ=10 ppm

C_s = cleanup standard = 100 ppm

μ_1 = 90 = an alternative cleanup decision level, $\mu_1 < C_s$

α = false rejection rate = 0.05, $z_{1-\alpha} = z_{0.95} = 1.645$

β = false acceptance rate = 0.1, $z_{1-\beta} = z_{0.90} = 1.282$

If one were to ignore the presence of several statistically homogeneous sub-populations (as identified using univariate population partitioning technique) in the sample of 30 observations, and use the sample variance of the 30 observations (3375.61) in the above sample size determination formula, then the resulting number of future samples will come out to be 288. Using the proposed population partitioning approach, the number of samples will be calculated (using descriptive statistics given in Table 2) for each of the sub-populations 1- 4 separately. These sample sizes are given in the following Table 3.

Table 3. Sample Sizes for Lead by Sub-Populations

Sub-population	Sample Variance	Sample Size n
1	0.749956	1
2	8.8209	1
3	219.9289	19
4	337.0896	29

This results in a total of 50 samples, a considerable reduction in the number of samples (=288) needed to be collected without population partitioning. Some additional samples may have to be collected to deal with the possibility of hot-spots (such as in sub-population 5) at the site. Defensible 95% upper confidence limits of the mean (e.g., as estimates of the exposure point concentration terms) can be computed for each of the sub-population using all (existing and future samples) of the data

5. Summary

We have shown, by using a simulated example, that the spatial population partitioning method, a combination of univariate population partitioning and Voronoi diagram works reasonably well when there is clear separation between the sub-populations obtained using univariate population partitioning technique. Therefore, instead of post-plots, for better spatial visualization of population partitioning results, one can use Voronoi diagram. We have also demonstrated the usefulness of the proposed approach: once the population partitioning method has been used to partition the site into the sub-populations, the confidence intervals for the mean contaminant concentrations for each sub-population can be computed and more informed cleanup decisions (e.g., estimation of the exposure point concentration terms) can be made for various parts of the site under investigation. The method can also be applied in the determination of the number of samples needed to characterize those parts of the site, which have not been sampled. In cases where future sampling is required, the proposed method of population partitioning will typically result in fewer samples and therefore, reduced sampling costs as shown in Example 3.

REFERENCES

[1] Singh, A. K., Singh, Anita, and Engelhardt, M. (1997), The Lognormal Distribution in Environmental Applications, EPA/600/R-97/006, December 1997.

[2] Singh, A. K., Singh, Anita, and Engelhardt, M., (1999), Some Practical Aspects of Sample Size and Power Computations for Estimating the Mean of Positively Skewed Distributions in Environmental Applications, EPA/600/S-99/006, November 1999.

[3] EPA, 1992. Supplemental Guidance To RAGS: Calculating the Concentration Term, Office of Emergency and Remedial Response, Washington, DC, Publication 9285.7-081.

[4] EPA, 2000. Data Quality Objectives Process for Hazardous Waste Site Investigations. EPA QA/G-4HW, Final.

[5] Singh, A., Singh, A.K., and Flatman, G (1994), Estimation of Background Levels of Contaminants, Mathematical Geology, Vol. 26, No. 3, p 361-388.

[6] Singh, A. and Singh, A.K. (1996), Trend Removal in Spatially Correlated Data Sets, Mathematical Geology, Vol. 28, No. 1, p 111-132.

[7] De Berg, M., Van Kreveld, M., Overmars, M. and Schwarzkopf, O. Computational Geometry: Algorithms and Applications, Springer, 1997.

[8] O'Rourke Joseph, Computational Geometry in C, Second Edition, Cambridge University Press, 1998.

[9] Jaromczyk, J. W. and. Toussaint, Godfried T, Relative Neighborhood Graphs and Their Relatives, Proceedings of the IEEE (Special Issue in Computational Geometry), 1992.

[10] EPA, 1991. A Guide: Methods for Evaluating the Attainment of Cleanup Standards for Soils and Solid Media, Office of Emergency and Remedial Response, Washington, DC, Publication 9355.4-04FS.

[11] Weber, Dennis and Englund, Evan (1992) Evaluation And Comparison Of Spatial Interpolators, Mathematical Geology, Vol. 24, p. 381-391.

[12] Weber, Dennis and Englund, Evan (1992) Evaluation And Comparison Of Spatial Interpolators II, Mathematical Geology, Vol. 26, p. 589-603.

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APPENDIX A

Table A1: Data Set for Example 2.
Normal Mixture with 10 observations from N(20,4), 100 from N(0,1), 30 from a N(5,1), and 2 extreme observations from N(100,10).

Easting	Northing	Conc	Easting	Northing	Conc
0	80	14.709	92.308	67.6923	0.651
7.692	80	26.828	100	67.6923	-0.253
15.385	80	19.583	0	61.5385	0.5
23.077	80	20.708	7.692	61.5385	0.994
30.769	80	21.756	15.385	61.5385	2.327
38.462	80	27.655	23.077	61.5385	-0.251
46.154	80	23.585	30.769	61.5385	1.331
53.846	80	17.35	38.462	61.5385	-0.612
61.538	80	27.182	46.154	61.5385	0.455
69.231	80	15.546	53.846	61.5385	-1.606
76.923	80	0.488	100	61.5385	0.022
84.615	80	0.706	0	55.3846	-0.795
92.308	80	1.259	7.692	55.3846	1.595
100	80	0.682	15.385	55.3846	-0.305
0	73.8462	0.286	23.077	55.3846	1.467
7.692	73.8462	-2.954	30.769	55.3846	-0.805
15.385	73.8462	-0.513	38.462	55.3846	-0.856
23.077	73.8462	-0.12	46.154	55.3846	0.441
30.769	73.8462	0.361	53.846	55.3846	-1.31
38.462	73.8462	-1.366	61.538	55.3846	0.32
46.154	73.8462	-1.129	69.231	55.3846	-1.118
53.846	73.8462	-0.45	76.923	55.3846	0.059
61.538	73.8462	-1.134	84.615	55.3846	-0.166
69.231	73.8462	-0.302	92.308	55.3846	-0.036
76.923	73.8462	-1.342	100	55.3846	1.951
84.615	73.8462	0.036	0	49.2308	-1.316
92.308	73.8462	0.328	7.692	49.2308	0.171
100	73.8462	0.037	15.385	49.2308	-0.005
0	67.6923	0.614	23.077	49.2308	-0.207
7.692	67.6923	0.746	30.769	49.2308	-0.472
15.385	67.6923	-1.204	38.462	49.2308	1.86
23.077	67.6923	-0.506	46.154	49.2308	-1.47
30.769	67.6923	-0.179	53.846	49.2308	0.44
38.462	67.6923	-0.102	61.538	49.2308	-0.415
46.154	67.6923	-0.483	69.231	49.2308	-1.685
53.846	67.6923	0.209	76.923	49.2308	1.061
61.538	67.6923	-1.01	84.615	49.2308	-0.218
69.231	67.6923	-0.484	92.308	49.2308	0.024
76.923	67.6923	-1.014	100	49.2308	-0.132
84.615	67.6923	0.214	0	43.0769	-0.836

Easting	Northing	Conc	Easting	Northing	Conc
7.692	43.0769	-0.003	76.923	24.6154	3.179
15.385	43.0769	0.258	84.615	24.6154	4.912
23.077	43.0769	-0.502	92.308	24.6154	5.529
30.769	43.0769	-0.676	100	24.6154	5.599
38.462	43.0769	1.268	0	18.4615	5.257
46.154	43.0769	-0.316	7.692	18.4615	6.121
53.846	43.0769	-0.061	15.385	18.4615	4.297
61.538	43.0769	1.455	23.077	18.4615	5.446
69.231	43.0769	0.531	30.769	18.4615	5.501
76.923	43.0769	1.25	38.462	18.4615	5.741
84.615	43.0769	1.441	46.154	18.4615	4.35
92.308	43.0769	2.043	53.846	18.4615	4.911
100	43.0769	-0.054	61.538	18.4615	3.686
0	36.9231	-0.562	69.231	18.4615	3.806
7.692	36.9231	-0.466	76.923	18.4615	5.038
15.385	36.9231	-0.922	84.615	18.4615	5.206
23.077	36.9231	-0.436	92.308	18.4615	5.525
30.769	36.9231	-0.801	100	18.4615	3.95
38.462	36.9231	0.823	0	12.3077	4.457
46.154	36.9231	-0.494	7.692	12.3077	5.07
30.769	30.7692	-1.045	92.308	0	98.178
38.462	30.7692	-1.388	100	0	100.267
46.154	30.7692	1.584			
53.846	30.7692	0.193			
61.538	30.7692	-0.065			
69.231	30.7692	0.82			
76.923	30.7692	-1.203			
84.615	30.7692	-0.69			
92.308	30.7692	-0.77			
100	30.7692	-0.419			
0	24.6154	3.366			
7.692	24.6154	3.513			
15.385	24.6154	5.541			
23.077	24.6154	4.957			
30.769	24.6154	5.111			
38.462	24.6154	6.282			
46.154	24.6154	3.933			
53.846	24.6154	6.824			
61.538	24.6154	4.96			
69.231	24.6154	4.803			

Changes and Improvements in the Ambient Air Quality Monitoring Program Quality System

Michael Papp, US EPA, OAQPS

The Clean Air Act (CAA) and its amendments provides for the implementation of an Ambient Air Quality Monitoring Program where air quality samples are generally collected for one or more of the following objectives:

- to judge compliance with and/or progress made towards meeting ambient air quality standards
- to activate emergency control procedures that prevent or alleviate air pollution episodes as well as develop long term control strategies
- to observe pollution trends throughout the region, including non-urban areas
- to provide a data base for research and evaluation of effects: urban, land-use, and transportation planning; development and evaluation of abatement/control strategies; and development and validation of diffusion models

A quality system for the Ambient Air Quality Monitoring Program has been developed that includes the implementation of various quality assurance and quality control techniques at the national, regional and monitoring organization levels. Over the years, new criteria pollutants have been added for comparison to the National Ambient Air Quality Standards (NAAQS) and new monitoring programs, such as the National Ambient Toxics Trends Sites, have been established. This paper will look at the changes and improvements that have been recently made or will be made to the program over the next year.

The Criteria Pollutant Network- Stable Yet Changing

Within the last 5 years, OAQPS and our partners in the monitoring community have taken a look at the implementation of the current monitoring network and have suggested some creative changes and new directions. The document entitled *National Ambient Air Monitoring Strategy*[1] describes these changes and how the monitoring program should incorporate new scientific findings and new technologies to help answer current health and environmental questions. The *Monitoring Strategy* recommends producing more insightful data by:

- including a greater level of multi-pollutant monitoring sites in representative urban and rural areas across the Nation
- expanding use of advanced continuously operating instruments and new information transfer technologies
- integrating emerging hazardous air pollutant (HAPs) measurements into mainstream monitoring networks
- supporting advanced research level stations

[1] http://www.epa.gov/ttn/amtic/monitor.html

A new national monitoring network design called NCore has been proposed to accommodate these recommendations and the major demands of air monitoring networks.

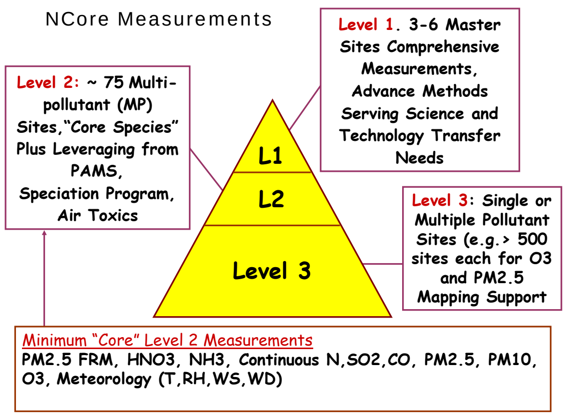


Figure 1 NCore Structure

Figure 1 illustrates the structure of the NCore network. In place of the current National Air Monitoring Station (NAMS)/State and Local Air Monitoring Station (SLAMS) programs, NCore will establish three levels of monitoring sites:

Level 1 – a more research-oriented platform accommodating the greatest level of instrumentation with specific targeted objectives;

Level 2 – the backbone network of approximately 75 nationwide multi-pollutant sites, encompassing both urban (about 55 sites) and rural (about 20 sites) locations;

Level 3 – additional sites, reasonably analogous to today's SLAMS sites, focusing primarily on those pollutants of greatest concern.

At the time the *Monitoring Strategy* was being developed, a Workgroup made up QA managers from EPA and the State, Local and Tribal monitoring organizations reviewed the quality system and proposed changes and improvements which are also included in the *Monitoring Strategy*. Since the Ambient Air Quality System requirements reside in 40 CFR Part 58 Appendix A, the QA Strategy Workgroup revised this document to keep what was relevant and add necessary requirements based on NCore objectives. In addition to restructuring this Appendix for readability, the following changes have been proposed:

- **Combined APP B into APP A**. Appendix B provides guidance for Prevention of Significant Deterioration (PSD) which is very similar to the Appendix A requirements so it was felt these two sections could be combined.
- **QMP and QAPP approval.** Provides more up-to-date information on quality management plans (QMPs) and Quality Assurance project plans (QAPPs).
- **Graded approach to QA.** Described this process in CFR in order to provide flexibility on the development of QMPs and QAPPs. A paper on this approach is available on AMTIC (http://www.epa.gov/ttn/amtic/geninfo.html.)
- **Quality assurance lead.** Provides for monitoring organizations to designate a quality assurance lead with certain QA responsibilities. A paper on this approach is available on AMTIC (http://www.epa.gov/ttn/amtic/geninfo.html)
- **Reporting organization and primary quality assurance organization**. Defines these two terms in order to clarify the organization primarily responsible for the quality of the data.

- **SO_2 and NO_2 manual audit checks** (formally 3.4.2 and 3.4.3) - Removed these sections since the manual methods are no longer in use.
- **Biweekly precision check and audit concentration range**- changed the ranges to allow for lower concentration checks to be acceptable in cases where the majority of the data from a site are below the current range requirements and to accommodate precursor gas monitoring.
- **PM_{10} collocation requirement.** Changed the requirement to 15% of routine sites; similar to $PM_{2.5}$
- **Provide for quarterly data certifications.** Due to the emphasis on real-time reporting, data quality validation and evaluation is occurring earlier in the monitoring process than in the past. In addition, the QA Reports distributed by OAQPS have limited usefulness because the data are not evaluated until after it is officially certified, typically 6 months after the calendar year in which it was collected. Certifications could occur sooner and quarterly data certification is being proposed.
- **Revised Automated Precision and Bias Statistics** - Changed statistics used to estimate precision and bias and will calculate them on a site basis as opposed to a reporting organization basis.

National Performance Evaluation Program- Change, Additions, Improvements

A critical element in any quality assurance program is the process of independent assessment. Independent assessment provides for a level of objectivity and consistency in the determination of data quality. OAQPS, in partnership with the EPA Regions and the National Environmental Research Laboratory (NERL), have always provided the function of independent assessment that includes: site characterization and network reviews, technical systems audits and performance evaluations. Performance evaluations (PE) are a type of audit in which the quantitative data generated in a measurement system are obtained independently and compared with routinely obtained data to evaluate the proficiency of an analyst or laboratory. A number of performance evaluation programs have been implemented by EPA including:

- National Performance Audit Program (NPAP)
- PM2.5 Performance Evaluation Program (PEP)
- National Air Toxics Trends Sites (NATTS) Proficiency Tests (PT)
- Round Robin Studies

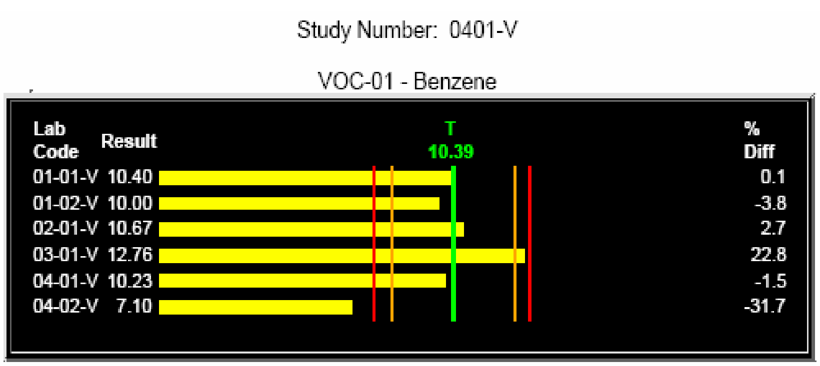
Certification programs- Certification programs provide some independent testing of products and or instrumentation and are used to provide a sense of quality and comparability. The following certification programs are being implemented for the Ambient Air Quality Monitoring Program

- Ozone Standard Reference Photometer Program (SRP)
- PAMS Cylinder Certification Program
- Protocol Gas Cylinder Verification Program

A few of these programs will be highlighted based upon recent improvements.

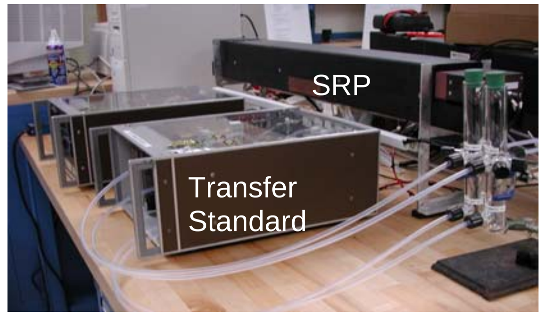
The National Performance Audit Program is a cooperative effort among OAQPS, the 10 EPA Regional Offices, the monitoring organizations that operate the SLAMS/NAMS/PAMS air pollution monitors and the organizations that operate air monitors at Prevention of Significant Deterioration (PSD) sites. The implementation goals of the NPAP are to audit all monitors in the Ambient Air Quality Monitoring Network (~3,000 sites) within a 5-year period while auditing higher priority monitors more frequently. NPAP provides audits for the criteria pollutants: ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, flow rate audit devices for particulate collection for PM10 and lead, and lead audit filter strips for the analytical labs analyzing for lead. From 1979 to 2000, NPAP operated as a mailable audit system. Audit standards and devices (flow rate orifices, audit gasses) were mailed to the monitoring organizations who challenged their monitors with these audit devices. In FY2001, EPA improved the audit program to a through-the-probe (TTP) system. The TTP is conducted using a self-sufficient mobile laboratory (audit van or trailer) to conduct the audits. The audit gas concentrations are generated and measured in the mobile laboratory and delivered to the station through a presentation line. This technique tests the integrity of the air monitoring station's entire sampling system. So far, 5 audit trailers and 1 audit van has been constructed and are in use in 6 EPA Regions. In addition, while not in use for auditing, the mobile laboratory can be used as a sampling platform which provides additional benefits to the EPA Regions as a monitoring and training facility.

The National Air Toxics Trends Sites (NATTS) Proficiency Test Program is the newest program and started in 2004 to provide data quality information for the NATTS network. A PT is a type of assessment in which a sample, the composition of which is unknown to the analyst, is provided to test whether the analyst/laboratory can produce analytical results within the specified acceptance criteria. Separate PT samples are developed for analysis of volatile organic carbon, carbonyls and metals. In addition, at least 1 audit of each type is sent to the National Institute of Standards and Technology (NIST) for characterization in order to evaluate the contractor developing the PTs. Laboratory results are evaluated against the contractors reported audit values and in relation to the warning and control limits set for the program. As information from the audits is accumulated, one may be able to discern patterns in individual labs and use this information in corrective actions. Two audits where implemented in 2004 and four are anticipated every year



thereafter. Results of these audits will be uploaded to the Ambient Monitoring Technical Information Center (AMTIC) Website.

The Standard Reference Photometer (SRP) Program provides a mechanism to establish traceability among the standards used by monitoring organizations with NIST. Every year NIST certifies an EPA SRP located in Las Vegas and operated by the Office of Radiation and Indoor Air (ORIA). Upon certification, ORIA ships this SRP (SRP#7) to the EPA Regions who use this SRP to certify their SRP that remains stationary in the Regional Lab. These stationary SRPs are then used to certify the ozone transfer standards that are used by the monitoring organizations who bring their transfer standards to the Regional SRP for certification. Over the last 2 years, the SRP software has been updated to make the certifications easier to perform. Since the SRPs are very sensitive, shipping SRP#7 around the country is risky and requires extreme care. ORIA is currently looking at alternatives and is presently studying the possibility of shipping a more rugged standard that would still maintain adequate traceability to NIST.



EPA Protocol Gases are used in quality control activities (i.e., calibrations, audits etc.) to ensure the quality of data derived from ambient air monitors used by the monitoring organizations. EPA developed the Protocol Gas Program to allow standards sold by specialty gas producers to be considered traceable to NIST standards.

In the 1980s and 1990s, the National Exposure Research Laboratory (NERL) of the EPA operated a nationwide audit on the vendors of Protocol Gas Standards. The intent of this program was to:

- increase the acceptance and use of Protocol Gases as standards by the air monitoring community,
- provide a quality assurance check for the vendors of these gases, and
- assist users of Protocol Gases to identify vendors who can consistently provide accurately certified Protocol Gases.

This program was discontinued in 1998. In 2002, there was interest by the gas vendors and EPA to reestablish this program. In 2003, EPA's Clean Air Marketing Division sponsored a performance audit to assess the accuracy of EPA Protocol Gases and the results suggested that that there was merit to implementing an audit program. The program is presently undergoing re-structuring with the potential for NIST to perform the audit function. A start-up in CY2006 is anticipated.

Assisting the Tribes in Development of QA Project Plans

Tribes, as are all organizations who use EPA funds, are required to develop quality assurance project plans (QAPPS) for their monitoring organization’s data collection activities. A QAPP describes the environmental data operations involved with the acquisition of environmental information in a manner that meets the data quality objectives of the program. The EPA Qualit

Staff provide both requirement documents and guidance (R-5 & G-5) on the development of QAPPs. However, organizations not familiar with EPA terms or with little experience in the development of quality systems have difficulty developing these documents and getting them approved by EPA. Over the past few years, OAQPS and the Tribal Air Monitoring Support Center (TAMS) have developed a number of generic QAPPs to assist the Tribes in developing project specific QAPPs. In order to make the development of QAPPs as simple as possible, EPA, in cooperation with the Institute for Tribal Environmental Professionals (ITEP), has funded the development of a software product, mimicking the functioning of software like Turbo-Tax, to lead tribal monitoring personnel through the development of their project specific ambient air monitoring QAPPs. Lakes Environmental has been awarded a contract to develop this software with a beta version expected by the end of 2005.

Annual Precision and Bias Reports – Providing a New View on the Air Quality System

As mentioned earlier, the QA Strategy Workgroup proposed new procedures for estimating precision and bias of the criteria pollutants. Annual summary reports for the data collected in calendar year 2003 was developed by Battelle and placed on the Ambient Monitoring Technical Information Center (AMTIC) Website (http://www.epa.gov/ttn/amtic/parslist.html). The summary reports provide an efficient way to sort data and some of the reports allow one to review graphical presentations of the data at the monitoring site level of aggregation. In 2005, OAQPS will be attempting to develop similar reports in the Air Quality System (AQS) database that will allow monitoring organization and OAQPS to generate these reports at will.

Precursor Gas Monitoring

The *Monitoring Strategy* includes the monitoring of precursor or trace gases of sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen oxide and total reactive nitrogen (NO and NOy). Monitoring these pollutants will require newer technology capable of measuring at low concentration levels. In 2004, OAQPS started testing these instruments and assessing the data quality indicators of detectability, precision and bias. In 2005, OAQPS will be partnering with a number of monitoring organizations to pilot the implementation of these new monitors. In addition, OAQPS will be developing a Workgroup to address the data quality objectives for this precursor gas monitoring activity using the data quality information from the pilot tests.

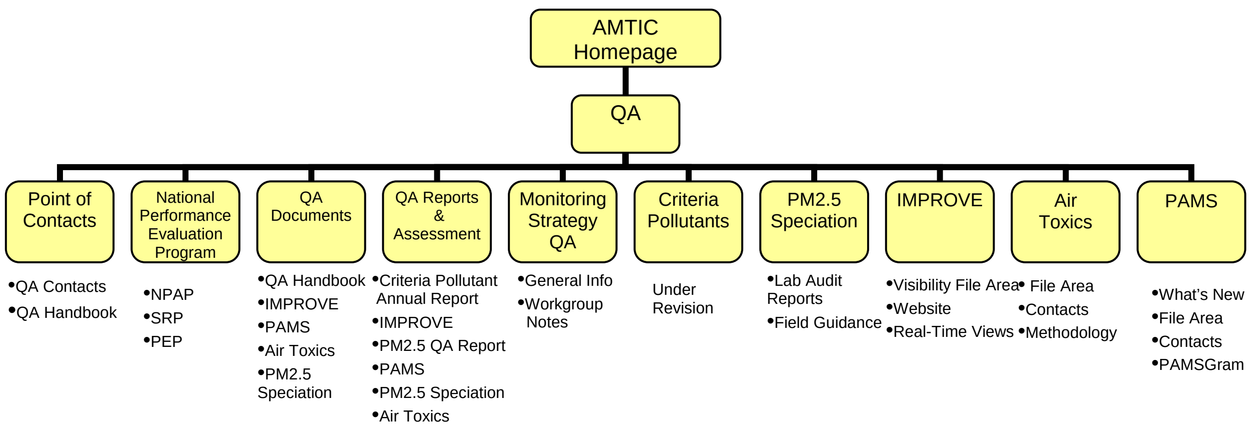
Improved Communication- Guidance and Websites

In 1998, a Workgroup made up of QA representatives from EPA and the monitoring organizations completed a revision of the *QA Handbook Volume II Part 1 the Ambient Air Quality Monitoring Program Quality System Development.* The intent of the document is twofold. The first is to provide additional information and guidance on the material covered in the Code of Federal Regulations pertaining to the Ambient Air Quality Monitoring Program. The second is to establish a set of consistent QA practices that will improve the quality of the nation's ambient air data and ensure data comparability among sites across the nation. The document is written for technical personnel at monitoring agencies and is intended to provide enough information to develop a quality system for ambient air quality monitoring. With major changes occurring to the monitoring program due to the *Monitoring Strategy*, OAQPS is in the process of revising the *QA Handbook*. Anna Kelley, the QA Manager at Hamilton County Department of Environmental Services, Cincinnati, Ohio, working for EPA on an intergovernmental personnel action, has led the QA Strategy Workgroup in a review and revision of this document. Completion of this QA Handbook is anticipated by July of 2006.

The Ambient Monitoring Technical Information Center (AMTIC) Website is the area where the OAQPS attempts to provide information, guidance, reports and data on the Ambient Air Quality Monitoring Program and its quality system. OAQPS is currently revising AMTIC to make it flow more logically and be more user friendly. The following flowchart illustrates how quality system information is mapped on AMTIC.

Map of Ambient Air Quality Assurance Website

http://www.epa.gov/ttn/amtic



Guidance for a New Era of Ambient Air Monitoring

Anna Kelley, Hamilton County Department of Environmental Services, Cincinnati, Ohio

The Clean Air Act of 1970 set National Ambient Air Quality Standards (NAAQS) for the criteria pollutants sulfur dioxide, ozone, carbon monoxide, nitrogen dioxide, total suspended particulate, and lead. Reference methods for collecting and analyzing the pollutants were established in the Code of Federal Regulations. Agencies charged with monitoring for the pollutants needed further information and guidance on the appropriate ways to execute all aspects of the monitoring program. In 1977, EPA released five separate volumes of guidance titled: ***Quality Assurance Handbook for Air Pollution Measurement Systems.*** Volume II Part 1 of this five volume set, deals specifically with the ambient air monitoring program. Undergoing a major revision in 1998, the document, referred to as the Red book in the ambient air monitoring community, was rewritten to better reflect current guidance in developing a quality system for ambient air monitoring programs. To emphasize the need for agencies to adopt the quality system approach, the revision of the Red book was written in the Quality Assurance Project Plan format.

The National Ambient Air Monitoring Strategy (NAAMS) in addition to other national monitoring programs recently instituted by EPA have prompted proposed changes to EPA's national monitoring program. At the same time, some quality assurance requirements are changing. To better support and provide the necessary guidance to State, Local and Tribal (S/T/L) agencies, the Red book is once again undergoing revision.

Using conference calls as the means to accomplish this task, quality assurance representatives of ambient air monitoring organizations from state, local, tribal, and EPA (both regional, OAQPS, and ORD) offices provided their recommendations on needed changes to the document to better reflect the proposed changes to ambient air monitoring network and give guidance in the development of a quality system. Without the combined efforts of this group of dedicated professionals, much needed insights may not otherwise be included in this document.

The completed revision will be available electronically as well as hard copy. Both an objective of the work group and a benefit to the electronic version of this revision is to provide hot links to the various topics for persons requiring a source of additional information.

Section 1

This section outlines the responsibilities of all organizations involved in the ambient air monitoring process. Introduced for the first time is the Primary Quality Assurance Organization. This terminology is contrasted with Reporting Organization. Both can be means for data assessment. A Reporting Organization is an organization that reports the data to AQS and may or may not also be responsible for an ambient air monitoring network. A Primary Quality Assurance Organization is responsible for set of monitors of the same pollutant and for which data assessments can be pooled.

Section 2 - Program Background

This section contains information on the many ambient air monitoring programs either operated or supported by OAQPS through monetary efforts. These programs include the new NCore sites, Special Purpose Monitoring (SPM), Photochemical Monitoring Assessment Stations (PAMS), National Air Toxic Trend Sites (NATTS), $PM_{2.5}$ Chemical Speciation Trends Network, Interagency Monitoring of Protected Visual Environments (IMPROVE), IMPROVE Protocol Sites, and Prevention of Significant Deterioration (PSD) Monitoring. In the proposed revisions to 40 CFR Part 58, Appendices A & B have been combined. Appendix B deals with PSD monitoring. A table containing both NCore and PSD is included in CFR listing the ambient monitoring and reporting requirements for both.

Other new information included in Section 2: the CFR requirements for each monitoring organization to have a Quality Management Plan (QMP), a Quality Assurance Project Plan (QAPP), the Graded Approach to developing the previous two mentioned documents and the Performance Based Measurement System. These latter two are designed to give flexibility to a monitoring agency in achieving its overall goals and objectives of a program. However, it should be noted a monitoring agency that receives funding from EPA and continues an ongoing monitoring program are required to have a separate QMP and QAPP. Additional updates in this section include the changes to the National Performance Audit Program and Data Assessment.

Section 5 - Documents and Records

Giving an overview of the types of documents and records a monitoring organization acquires and retains, a major change to this section is the discussions involving the handling and storage of electronic records. Today these types of records are more a part of ambient monitoring than in previous years. The need for this type of data is discussed at length in the NAAMS document and will become more evident as the monitoring strategy continues to unfold.

Proper documentation and archival of data is discussed in terms of admissible evidence. To ensure the authenticity of the data, the section describes the various types of data records to be kept. A monitoring organization’s Quality Management Plan (QMP) and Quality Assurance Project Plan (QAPP) are to document the data trail and how all data records are to be handled. Standard Operating Procedures (SOP), a required element of a QAPP, should list in detail record retention and archival and the exact steps to be taken to ensure this.

Section 14 – Data Acquisition and Information Management

Section 14 discusses in depth real time data acquisition, the quality control of the data, and the reporting of the data. Pushed by ever changing technology and the need for real time ambient air monitoring data, the analog systems used by a number of monitoring organizations will be moving to digital acquisition, another goal of NAAMS. The process of data acquisition is discussed in length involving a step by step process of the data trail from generation to storage. The need for quality control is discussed with steps provided to users to assist the data verification process.

Guidance concerning the treatment of outlier data is added to this section. Outlier data is defined as “measurements that are extremely large or small relative to the rest of the data and are suspect of misrepresenting the population of data from which they were collected.”[1] This is an area the monitoring organizations have faced for many years but each has dealt with individually. The information given in this handbook brings to the attention of monitoring organizations a uniform manner EPA recommends in dealing with these types of data.

In the area of information management, an appendix is provided as an example of data acquisition, management and archival. This is available for monitoring organizations to review, use, and/or revise to better fit their situations.

Next Steps

There are other sections of Red book yet to be revised. As with any dynamic program, more information is found to be incorporated in this guidance document. Before it is completed, additional information may be added to those sections already completed. The next sections to be completed include Sections 6 & 7.

Sections 6 will explain the concept of NCore and its different levels, its objectives and the sampling process of setting up not only this system but any ambient air monitoring network.

Sampling methods particularly sampling designs are the subject of Section 7. The pros and cons of each one with regard to US EPAs objectives for performance evaluations are included.

Other sections will include updated information on the Data Quality Objective process and qualifications and training of personnel for ambient monitoring networks.

Environmental Monitoring Quality Assurance in Indian Country

M. Ronca-Battista[1]

24th Annual National Conference on Managing Environmental Quality Systems
San Diego, California

The Tribal Air Monitoring Support (TAMS) Center is a cooperative program of Northern Arizona University and the US EPA. Our mission is to build tribal capacity to manage environmental programs of all kinds. With a very small staff, we focus on efficient forms of delivering training and practical assistance to tribes planning and conducting monitoring and evaluating and reporting data. We serve organizations dispersed across 3000 miles, many of who are in remote areas, so we must use innovative and cost-effective forms of communication. One of our key strategies is to use the relatively new programs and personnel in Indian Country as an opportunity to use quality assurance planning techniques they way they Ashould@ be used, from the beginning, as a value-added process, and in every phase of the data gathering and evaluation. Our focus is on the practical demonstration of the cost savings benefits of using, for example, the data quality objectives process early in the project. In addition, we are a Acomplete the loop@ program that provides assistance with data management, evaluation, and reporting, using the quality objectives agreed upon during planning.

There is much that the larger environmental community can learn from the experiences in using quality assurance as practical and efficient backbone to small-staffed programs in Indian Country. When only several people are responsible for air, water, and solid waste programs, there must be a shared philosophy, core knowledge and skills, and efficient communication. We deliver tools that can be used by the programs as a whole, integrated with existing systems, and used progressively in module format. These tools include a wide variety of document, data analysis, and database templates. In addition, we have online and CD-based courses that can support the use of these tools and general concepts.

This paper will describe the lessons learned about incorporating quality assurance into several tribal environmental data-gathering programs, effective methods of delivering the tools as well as the concepts needed, and the plans for making these tools available to a wider audience.

[1] Northern Arizona University – Tribal Air Monitoring Support Center

Scalable QAPP IT Solution for Air Monitoring Programs

Camille S. Drouin[1], Melinda Ronca-Battista[2], Michael Papp[3], Dr. Jesse L. Thé[1]

24th Annual National Conference on Managing Environmental Quality Systems
San Diego, California

ABSTRACT

There are over 500 federally recognized tribes in the US, and, like all grantee organizations, Tribes are required to prepare Quality Assurance Project Plans (QAPPs) for all data collection activities. The US EPA Quality Staff and the Tribal Air Monitoring Support Center (TAMS) are building tribal capacity for air monitoring. One critical element in this effort is to simplify and automate data quality assurance procedures.

This paper describes a unique QAPP Information Technology (IT) solution. The authors will present software functional implementation to facilitate the development of a wide variety of QAPPs. The QAPP software will prompt the users to answer series of questions similarly to the Turbo-Tax program and results in a QAPP report in an EPA approvable format. The questions generated are based on the proposed EPA Quality Staff guidance (R-5/G-5), TAMS Center Pollutant Specific model QAPPs, the OAQPS PM2.5 model QAPP, and quality control requirements. The presentation of the methodology will focus on data quality objectives.

Quality Assurance Project Plans can be time consuming to complete. This automated solution simplifies and automates the process, while providing support to both small and large organizations. It will make writing QAPPs a value-added process that helps users clarify and communicate their goals. By streamlining the often-repetitive text entry and comparison process, users can focus on key parameters that impact the conclusions that can be drawn from their planned program. The QAPP IT solution is a complete stand alone application that includes context-sensitive "Help that really helps" files. The solution was developed in a way to allow for its integration into other software packages, such as the Tribal Emissions Inventory Software Solution (TEISS).

While the QAPP IT solution is still in its infancy, it has great potential for providing a simple, cost effective QAPP development process, and flexibility to allow further modification to enable the incorporation of data collection programs in other media, such as water quality, radiation monitoring, or hazardous waste.

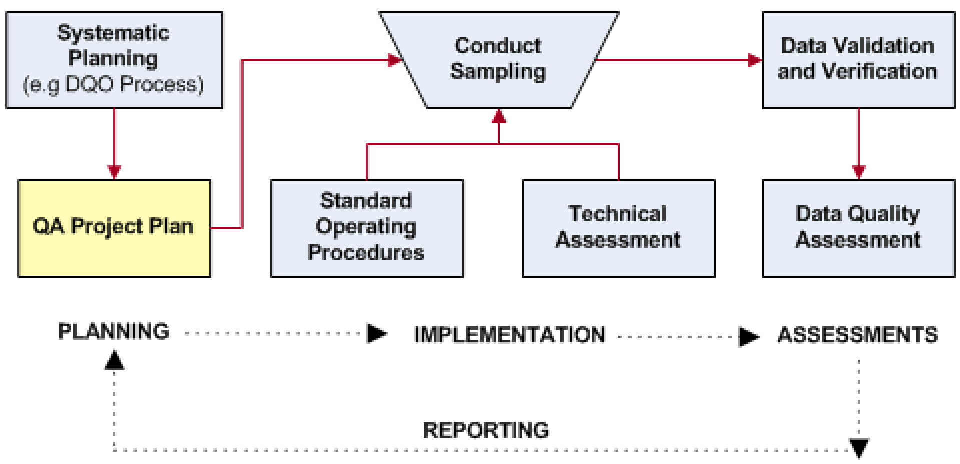
[1] Lakes Environmental Software
[2] Northern Arizona University – Institute of Tribal Environmental Professional (ITEP)
[3] Environmental Protection Agency – Office of Air Quality Planning and Standards (EPA OAQPS)

INTRODUCTION

Tribes, as are all grantee organizations who use Federal funds, are required to develop QA project plans (QAPPs) for their monitoring organization's data collection activities. Even Tribal environmental offices that are not using EPA grant funds develop QAPPs to ensure that their measurement results will be defensible.

The QAPP is a formal document describing in comprehensive detail the necessary QA/QC and other technical activities that must be implemented to ensure that data gathered will satisfy the required performance criteria such as data quality objectives (DQOs). The QAPP documents the planning, implementation, assessment and reporting procedures of a project, and how specific quality assurance and quality control procedures will be applied during project implementation. It is an invaluable exercise to write a QAPP prior to collecting data because it serves as the focal point for documentation and communication about the project. The Northern Arizona University's (NAU) Tribal Air Monitoring Support Center uses the QAPP-writing process as a way to assist Tribes plan and conduct their monitoring.

Figure 1: Defensible Products and Decisions



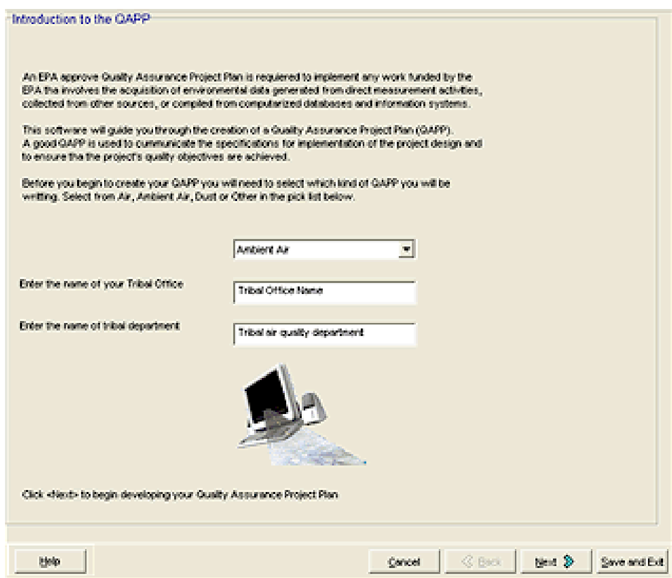
The EPA is responsible for developing the necessary tools and guidance so that monitoring agencies can effectively implement their monitoring and QA programs. EPA uses international consensus standards (American National Standards Institute and parallel international organizations) as a framework for their recommendations and requirements. The EPA Quality Staff provide both requirements and guidance (R-5 & G-5) on the development of QAPPs. In an effort to provide additional assistance over the past few years, the US EPA Office of Air Quality Planning and Standards (OAQPS) has developed Model QAPPs for the newer programs ($PM_{2.5}$, $PM_{2.5}$ Speciation, and Toxics Monitoring). In addition, the ambient air program provides guidance, definitions, and examples of quality system attributes and data quality indicators which are used in program-specific QAPPs. In the last year, the TAMS center has also developed pollutant specific "template" QAPPs to assist the Tribes in developing QAPPs. However, organizations not familiar with EPA terms or without formal quality systems may have difficulty developing these documents and getting them approved by EPA. In addition, the "model organization" used in the development of US EPA and international consensus standards is ***not*** a small, holistic, media-and functionally-integrated program as are most tribal environmental offices.

To facilitate the development of EPA-approvable QAPPs from Tribes, the Turbo-QAPP software was conceived.

QUALITY ASSURANCE PROJECT PLAN SOFTWARE

The Turbo-QAPP is a unique solution to automate and simplify the development of quality assurance project plans. The Turbo-QAPP is designed to "walk" the user through a series of questions using easily-understandable screens and examples, which the user can modify. The first screen is shown in figure 2. It is designed for use by tribal departments whose experience may range from extensive to limited, but in all cases provides easily-navigated definitions and examples of QA terminology and principles. Those who do not need such supplemental information examples can use the software to automate repetitive tasks, while those who need or are interested in more in-depth assistance can use a wizard or hyperlinks to jump to a definition or example. Users can work on different parts of their QAPP by using the Navigation toolbar, leaving sections that require additional information for later completion. The software indicates sections that have been worked on, that need more information, as well as those that are complete.

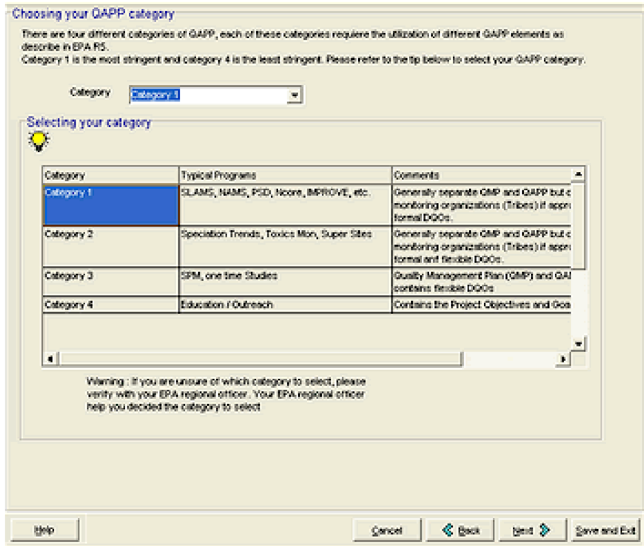
Figure 2: Turbo-QAPP software interface displaying the Introduction window.



Categories

Users begin by choosing which category of quality assurance project plan they are writing (see figure 3). The categories are based on the graded approach proposed by OAQPS for the development of quality management plans and QAPPs. Categories determine which elements of the QAPP must be included in the report to meet the EPA requirements. An educational or outreach program does not need to include all elements of a QAPP as opposed to a NAMS or SLAMS program where all elements would be required. In most cases, users will complete a QAPP using all of the 24 elements recommended in the consensus standard.

Figure 3: Turbo-QAPP software interface displaying the Category window.

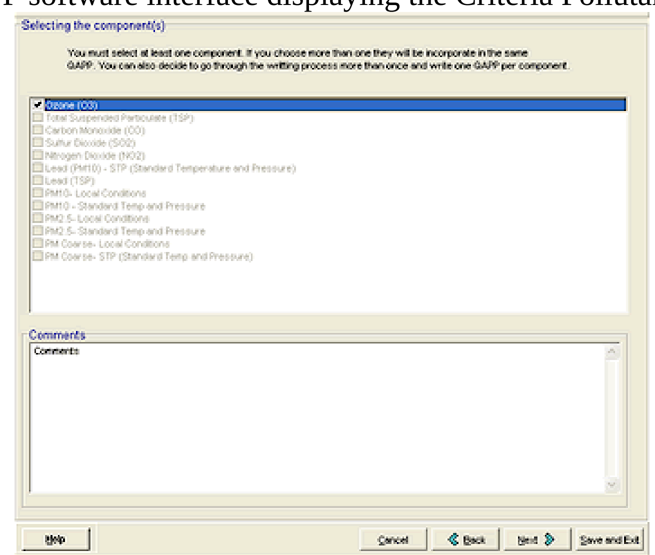


Criteria Pollutants

The current software design is for 13 criteria pollutants that monitoring organization can select for QAPP development. Turbo-QAPP can handle multiple or single pollutants in one QAPP. The selection of the pollutant is made before the user starts to write the QAPP, although the selection of "other" is also allowed. The Turbo-QAPP generates a drop-down pick-list and guidance that is specific for the selected pollutant (see figure 4).

To reduce erroneous entries that may arise when developing a QAPP for two more than one pollutant, the user completes the wizard once for each criteria pollutant selected. After the QAPP is complete for all the pollutants selected, the user can decide if he/she wants one or separate QAPPs for all of the pollutants.

Figure 4: Turbo-QAPP software interface displaying the Criteria Pollutant window.

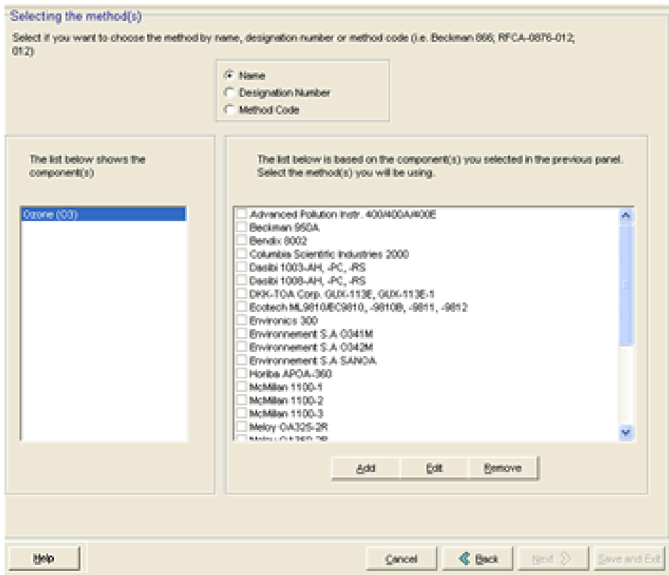


Methods

Turbo-QAPP provides a complete list of all the designated reference and equivalent methods for measuring ambient concentration of specific air pollutants (figure 5). Once the criteria pollutant is selected, the user is able to view a complete list of the methods that can be used to measure that specific pollutant. The method list is displayed by name, EPA designation number, and method code.

Designated references and method codes are periodically updated. To capture these changes, Turbo-QAPP is equipped with an [Add] button to allow the user to add methods.

Figure 5: Turbo-QAPP software interface displaying the Method Selection window.



Development of the QAPP System

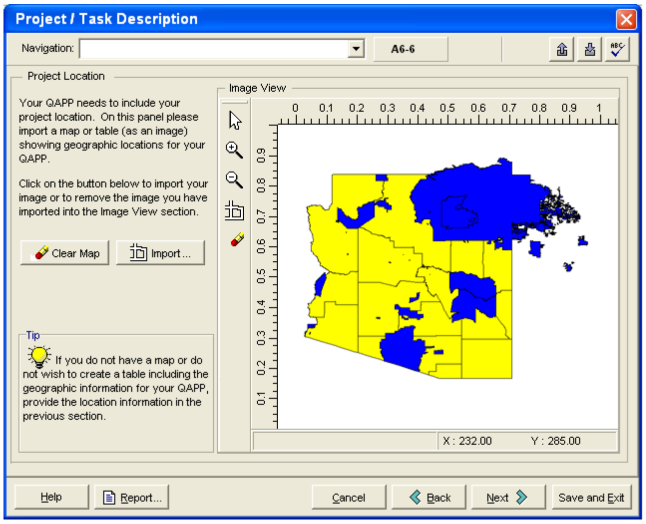
During the development of the QAPP the user is prompted to answer questions, and enter details for each element of the QAPP. The user is only prompted once for redundant information and the Turbo-QAPP stores this information so that it automatically populates elements and tables as needed.

The Turbo-QAPP uses the same four sections and 24 elements as the EPA guidance: (A) Project Management, (B) Data Generation and Acquisition, (C) Assessment and Oversight and (D) Data Validation and Usability. The software does not ask for the information for each section in the same sequential order as the 24 elements, however. It approaches the task of writing a QAPP using a common sense approach of dealing with the important questions first, i.e., why monitoring is being conducted. Ideally, this question would drive the development of all QAPPs, but writers often get bogged down in preliminary information such as organization charts and signature pages. To avoid this, Turbo-QAPP *first* asks for information on the basic purposes of the monitoring effort. Because of this, some elements of the main section are "populated" by entries made during the completion of other sections. When all the missing information is filled the user will have completed all the required elements of his QAPP. This ensures that the EPA review process of the final document goes smoothly.

Importing Maps and Images

Maps and images can be imported in Turbo-QAPP as long as they are in one of many importable formats such as Shapefile, Bitmap, JPEG, DLG, etc. Users can include maps such as the site location and images such as organizational charts for the monitoring organization (figure 6).

Figure 6: Turbo-QAPP software interface displaying the area to import the site location



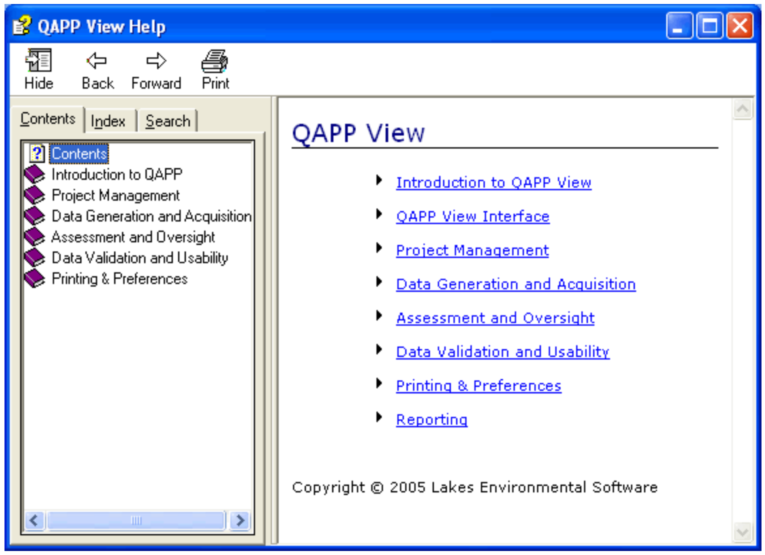
Database Management

Turbo-QAPP utilizes Microsoft Access as the database for storage and retrieval of QAPPs. This database is readily accessible to all and can be used on computers with low memory footprint and software requirements. This will ensure that Tribes using older version of Windows such as Windows 98 will be able to create QAPPs without having to purchase additional software to support the Turbo-QAPP software. The system can also work with Microsoft MSDE (available free online) and MS-SQL Server.

Help

Complete help files and links to EPA guidance are incorporated in Turbo-QAPP and are accessible at the click of the mouse (figure 7). The Tribes will also be provided with a user's guide that contains a tutorial. Lakes Environmental is proud of its help files that are easy to use to find pertinent information quickly.

Figure 7: Turbo-QAPP Help Files dialog.



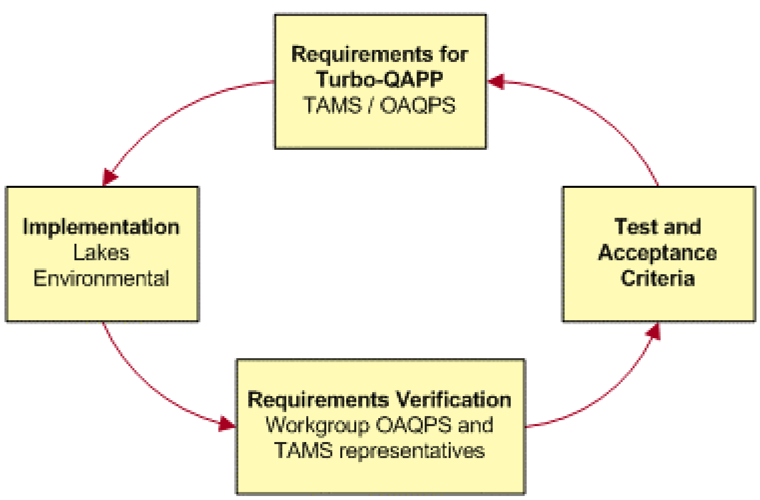
Reports

The output of the Turbo-QAPP is in the form of printable Microsoft Word documents. This will allow the QAPP to be modified using Word or another word processing program.

QUALITY ASSURANCE PROJECT PLAN DESIGN

The development of the QAPP System was planned and designed to ensure that all requirements and functionality for the Turbo-QAPP were implemented. When the requirements and functionality are implemented they must be approved for quality. Figure 2 illustrates the procedures followed for the testing and acceptances of the requirements.

Figure 8: Procedures for tests and acceptance of requirement changes

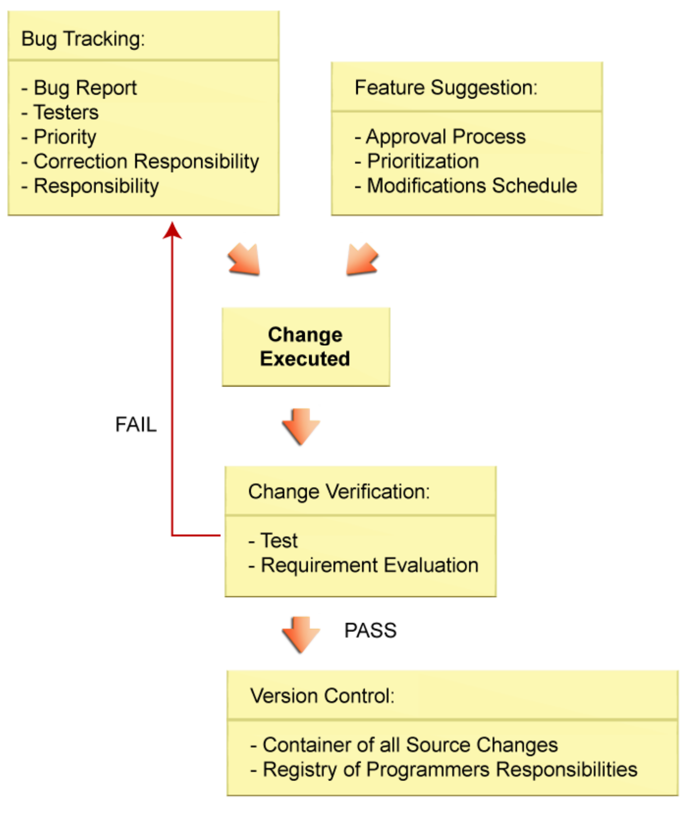


Small changes to the software development are noted as software defects (also known as a bug). Various types of software defects can be present in software, such as ones that cause complete computer shutdown, to minor message typos. All bug corrections and usability enhancements must be tracked by two specialized software applications called the “bug-tracker” and the “version control”.

To register all reported and detected software defects *Lakes Environmental* developed a program called the “BugTracker”. This program associates and prioritizes the bugs to the finder and assigns responsibility for fixes. Once the programmer corrects a bug, it should again be tested to verify “correction-as-required”. The BugTracker does not close a defect item until these steps are successfully completed. BugTracker will never delete a reported defect, it will only close it and keep it away from other open bugs.

Once sets of software defects are corrected a new product version is created. All the software code developed, prior and after the new version, is stored in a special code database versioning system, called a version control. This is crucial in case a previous version needs to be investigated for missing functionality.

Figure 9: Software defect and usability enhancement documentation procedure



CONCLUSION

Turbo-QAPP is a unique solution that simplifies and automates the creation of quality assurance project plans for the Tribes based on the EPA and TAMS guidance. Turbo-QAPP can be used by staff with limited experience with air monitoring programs as well as those with extensive air monitoring experience.

The Turbo-QAPP was originally developed for the Tribes to provide a simple, cost effective QAPP development process. However, its flexibility allows for potential future uses to include incorporation of data collection programs in other media, such as water quality, radiation monitoring, or hazardous waste with minimal modifications. As a complete stand-alone application, Turbo-QAPP can also be incorporated to other software such as the Tribal Emission Inventory Software Solution (TEISS).

REFERENCES

Lakes Environmental Software Inc, October 2004. *Quality Assurance Project Plan - Implementation Plan*. Lakes Environmental Consultants Inc., Waterloo, Ontario, Canada

U.S. EPA. August 2000. *Guidance for Data Quality Objectives Process: QA/G-4*. U.S. Environmental Protection Agency, Office of Environmental Information Research Washington, DC. http://www.epa.gov/quality1/qs-docs/g4-final.pdf

U.S. EPA. August 2004. *List of Designated References and Equivalent Methods.* U.S. Environmental Protection Agency, Office of Research and Development, Triangle Park, North Carolina. http://www.epa.gov/ttn/amtic/files/ambient/criteria/ref804.pdf

U.S. EPA. March 2001. *EPA Requirements for Quality Assurance Project Plans*: QA/ R-5. U.S. Environmental Protection Agency, Office of Environmental Information Washington, DC http://www.epa.gov/quality1/qs-docs/r5-final.pdf

U.S. EPA. December 2002. *Guidance for Quality Assurance Project Plans: QA/G-5*. U.S. Environmental Protection Agency, Office of Environmental Information Washington, DC http://www.epa.gov/quality1/qs-docs/g5-final.pdf

U.S. EPA. August 1998. *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II part 1: Ambient Air Quality Monitoring Program Quality System Development*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Triangle Park, North Carolina. http://www.epa.gov/ttn/amtic/files/ambient/qaqc/redbook.pdf

U.S. EPA. January 2000. *Guidance on Technical Audits and Related Assessments for Environmental Data Operations: QA/G-7*. U.S. Environmental Protection Agency, Office of Environmental Information Washington, DC http://www.epa.gov/quality1/qs-docs/g7-final.pdf